DEVELOPMENT OF A STEM BASED ENGINEERING DESIGN CURRICULUM FOR PARENTAL INVOLVEMENT IN EARLY CHILDHOOD EDUCATION

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ABSTRACT

DEVELOPMENT OF A STEM BASED ENGINEERING DESIGN CURRICULUM FOR PARENTAL INVOLVEMENT IN EARLY CHILDHOOD EDUCATION

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The purpose of the current study was to design and develop a STEM (Science, Technology, Engineering, Mathematics) based engineering design curriculum that addresses to preschool children, parents, and preschool teachers (EDCPI). In this context, the first aim of this study was to identify the key design principles in designing a STEM-based engineering design curriculum for parental involvement (PI) in early childhood education. The second aim was to explore the possible contributions of the developed curriculum to preschool children, parents, and preschool teachers. In line with the purposes of the study, design-based research methodology was utilized, and the study was carried out in three iterative phases: preliminary research, prototyping, and assessment. The designed content was revised, evaluated, and redesigned through three different iteration cycles in the prototyping phase of the study. The study was conducted with participants from two different public schools in Kastamonu. Findings validated eight main characteristics of EDCPI identified in the relevant literature and revealed that EDCPI made a wide variety of contributions to preschool children, parents, and preschool teachers. Based on the findings obtained from the study, it can be concluded that EDCPI can be helpful not only in supporting preschoolers' STEM-related learnings but also in building a bridge between families and schools. Therefore, the curriculum designed and developed within the scope of the current study provides a new and alternative way for the integration of STEM into preschool settings and for PI in early childhood education.

Keywords: Early Childhood Education, Engineering Education, Early Engineering Curriculum, Curriculum Development, Preschool Children, Parental Involvement.

ÖZ

OKUL ÖNCESİ EĞİTİMDE STEM TEMELLİ AİLE KATILIMLI BİR MÜHENDİSLİK TASARIM MÜFREDATININ GELİŞTİRİLMESİ

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Bu çalışma okul öncesi çocuklar, ebeveynler ve okul öncesi öğretmenlerine hitap eden STEM (Fen, Teknoloji, Mühendislik, Matematik) temelli ve aile katılımlı bir mühendislik tasarım müfredatı (EDCPI) tasarlamayı ve geliştirmeyi hedeflemektedir. Bu bağlamda, ilk amaç, okul öncesi eğitimde STEM temelli ve aile katılımlı bir mühendislik tasarım müfredatı tasarlarken dikkate alınması gereken temel tasarım ilkelerini belirlemektir. Diğer amaç ise, geliştirilen müfredatın okul öncesi çocuklar, ebeveynler ve okul öncesi öğretmenlerine olası katkılarını araştırmaktır. Çalışmanın amaçları doğrultusunda, tasarım tabanlı araştırma metodolojisi kullanılmıştır. Bu bağlamda, çalışma ön araştırma, prototip geliştirme ve değerlendirme aşaması olarak adlandırılan üç yinelemeli aşamada gerçekleştirilmiştir. Tasarlanan içerik, araştırmanın prototip geliştirme aşamasında üç farklı yineleme döngüsü boyunca gözden geçirilmiş, değerlendirilmiş ve yeniden tasarlanmıştır. Çalışma Kastamonu'daki iki farklı devlet okulundan katılımcılarla gerçekleştirilmiştir. Bulgular, EDCPI'nın ilgili alanyazın ışığında tanımlanan sekiz temel özelliğinin doğrulandığına ve EDCPI'nın okul öncesi çocuklara, ebeveynlerine ve okul öncesi öğretmenlerine çeşitli katkılar sağladığına işaret etmektedir. Çalışmadan elde edilen bulgulara dayanarak, EDCPI'nın yalnızca okul öncesi çocukların STEM ile ilgili öğrenmelerini desteklemede değil aynı zamanda aileler ve okullar arasında köprü kurma konusunda da yardımcı olabileceği sonucuna varılabilir. Bu nedenle, bu çalışma kapsamında tasarlanan ve geliştirilen müfredat STEM'in okul öncesi eğitim ortamlarına entegrasyonu ve okul öncesi eğitimde aile katılımı için yeni ve alternatif bir yol sunmaktadır.

Anahtar Sözcükler: Erken Çocukluk Eğitimi, Mühendislik Eğitimi, Okul Öncesi Dönem Mühendislik Müfredatı, Program Geliştirme, Okul Öncesi Çocuklar, Aile Katılımı.

To my beloved father Kemal ATA and mother Meliha ATA

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LIST OF ABBREVIATIONS

EDCPI	Engineering Design Curriculum for Parental Involvement
ECE	Early Childhood Education
EEE	Early Engineering Education
STEM	Science, Technology, Engineering, and Mathematics
EDP	Engineering Design Process
PI	Parental Involvement
DAP	Developmentally Appropriate Practices
MoNE	Ministry of National Education
DBR	Design Based Research
OBADER	Family Support Education Guide Integrated with ECE Program
NRC	National Research Council
NAE	National Academy of Engineering
NGSS	Next Generation Science Standards

CHAPTER 1

INTRODUCTION

STEM education (Science, Technology, Engineering, and Mathematics), first proposed as an educational reform for K-16 education in the United States is an educational approach aimed at preparing children to the global economy of the current century (Yakman & Lee, 2012). To that end, STEM focuses on enhancing the academic achievement of children and equipping them with the critical knowledge for future's labor force (Quigley & Herro, 2016). Indeed, STEM education which provides children with lifelong learning engages them in real-life problems and provides them with research-based and first-hand learning experiences. In this respect, it is seen as a necessity to cope with future problems and to preserve the quality of life (Van Meeteren, & Zan, 2010). In line with this, integrating and developing STEM education in all levels of education has become the focus of policy developers, researchers, educators, and parents in recent years (Carlisle & Weaver, 2018; Dubosarsky, John, Anggoro, Wunnava, & Celik, 2018).

Engineering which is one of the disciplines that make up the STEM acronym focuses on solving problems, designing or redesigning objects and systems by considering the needs and expectations of the society (Smetana, Schumaker, Goldfien, & Nelson, 2012). Engineering is based on solving human problems in a systematic way by taking advantage of science, technology, mathematics, and creativity. Therefore, it is possible to knead various knowledge and skills from all STEM disciplines in only one engineering activity (Stone-MacDonald, Wendell, Douglass, & Love, 2015). In other words, engineering promises to enhance the opportunities of integration with all STEM fields (Bagiati & Evangelou, 2015) and also other fields such as arts and literature (English, 2018).

As today's society becomes more and more dependent on technology and engineering, it is a requirement for everyone to understand what engineers do, and the areas of usage and applications of the technologies produced by engineers (Cunningham, 2009). Although the outcomes of engineering exist all around our lives, many people lack knowledge regarding what engineering is and what engineers engage with. On the other hand, technologies ranging from household appliances to toys and complicated systems are the products of engineering. In this respect, engineering has shaped societies for centuries, changing the world and improving the quality of life of societies (Stone-MacDonald et al., 2015). In today's world, where most of us spend 95% of the day in human-made areas like school, playground and home and interact with many human-made products from shoes to smartphones, it's not too early to teach engineering knowledge and skills to children and to help them appreciate the engineering (Davis, Cunningham, & Lachapelle, 2017). Indeed, understanding the human-made world where we live depends on the increase in engineering and technology knowledge and skills of every person, even young children (Cunningham, 2009).

Engineering education refers to providing children with the opportunity to solve problems which have a practical or societal significance by experiencing engineering design process (EDP) (National Academies of Science, Engineering, and Medicine, 2017). Besides, engineering education contains to provide children with examples of engineering from daily life, to introduce children to the challenges addressing by engineers working in different fields, and to understand the value of engineering in increasing the quality of life (Smetana et al., 2012). From this aspect, engineering education enables children to understand the constructed world (Cunningham, 2009). At this point, the innate curiosity of children to the world around them and their motivations to build and explore the answers to their questions makes early childhood an ideal time to begin engineering education (Elkin, Sullivan, & Bers, 2018).

Preschool children are emergent engineers. From their earlier years, children display many of the central skills required for complicated problem-solving processes in engineering design, such as identifying a problem, producing solutions, comparing various solutions by examining them to reveal the best solution (Bagiati & Evangelou, 2011; Van Meeteren & Zan, 2010). In addition, preschool children have some common aspects with engineers such as being curious, creative and process-oriented (Torres-Crespo, Kraatz, & Pallansch, 2014). Just like engineers, preschoolers are very successful in defining problems or needs, addressing defined problems or needs, developing and testing solutions, collaborating with peers and exchanging ideas. (Bagiati & Evangelou, 2016). Indeed, design ideas that include the practices of the EDP might be novel to educators but are not to children (Purzer & Douglas, 2018). On the contrary, preschool children are highly skilled in sorting out age-appropriate engineering-based problems and do so on a daily basis (English, 2018). For example, during a dramatic play activity, children can conclude that their teddy bear needs a house with a roof and door. Thus, they can decide to work to create such a house and to test the house, repeatedly, to see if it is suitable for the bear (Lottero-Perdue et al., 2016). Similarly, during the building activities, children find the chance to identify, address and solve engineering design problems in a natural context. For instance, while children build a castle for people or a corral for horses, they choose from accessible building stuff and bring them together in diverse forms by considering the function (Is my fence high enough that the horses cannot jump?), the strength

(Do the walls sustain the roof?), and the steadiness (How can I ensure the castle is not overturned?) of their structure (Hoisington & Winokur, 2015).

As innate engineers, young children design their own products, break up objects into pieces and discover with great pleasure how systems work (Cunningham, 2009). Engineering education can awaken children's curiosity and interest and motivate them to continue their work. In addition, the perspectives gained through engaging in engineering enable children to understand that engineering work is a creative initiative that deeply affects our world. In this way, children will be able to understand the value of science and engineering, and their contribution to coping with many of the challenges today societies face (e.g. prevention and treatment of diseases, maintenance of freshwater and food resources, production of sufficient energy, management of climate change) (Next Generation Science Standards [NGSS] Lead States, 2013).

Engineering education provides to present children with scientific concepts in realistic and interesting contexts and to integrate learning in different content areas (Moore, Tank, & English, 2018). In fact, engineering enables children to experience and learn not only the engineering content but also the concepts specific to other STEM disciplines from an early age. For instance, a building activity may be a good opportunity for the child to observe the properties of materials and the effect of forces such as gravity and friction on the movement of materials (Hoisington & Winokur, 2015). Similarly, thanks to an engineering activity in the block area, the child can experience that large and flat bases are more durable than long and thin bases when s/he wants to build something (Stone-MacDonald et al., 2015). In fact, mathematics and science-related ideas can be abstracted and generalized by children in a more complicated manner and at a younger age, than earlier considered. This complex way of thinking and reasoning for young children supports early engineering knowledge and skills, as well as providing a foundation for other content areas of the STEM (Moore et al., 2018).

Despite promising evidence of the impact of STEM and especially engineering education in preschool years on children's problem-solving skills and future success in both their daily lives and school life (Dubosarsky et al., 2018), preschool children have a very limited opportunity to meet engineering and technology-related content (Bagiati, 2011). In other words, engineering, one of the key areas of STEM, tends to be overlooked in early childhood, which is the important and formative years for fostering children's awareness of and interest in engineering and EDP (English, 2018). Fortunately, in recent years, research has focused on bringing engineering education to the preschool classrooms and children have found the opportunity to develop their engineering thinking, knowledge, and skills. However, there are not yet developed standards for engineering education for the preschool years

(Bagiati, Yoon, Evangelou, & Ngambeki, 2010), and there is a handful of research-based engineering curricula that define an explicit teaching philosophy, learning objectives, and assessment tools (Bagiati, 2011; Dubosarsky et al., 2018). In a similar vein, Turkish early childhood education (ECE) curriculum (Ministry of National Education [MoNE], 2013) includes very limited content for the disciplines of engineering and technology (Ata-Aktürk, Demircan, Senyurt, & Cetin, 2017).

A comprehensive curriculum is a key point for teachers and other educators to make regardfully decisions about what to teach and how. Such a curriculum offers a blueprint to plan and apply a program to address all dimensions of child development and build partnerships with families (Dodge, 2004). As Bronfenbrenner emphasizes, the child grows up in a complex system of different layers and take place at the center of this system (Berk, 2013). Both the family and school are important components of the child's immediate environment (Hayes, O'toole, & Halpenny, 2017), and as Papert defends, the child needs the learning opportunities provided by these two components (Ackerman, 2001). Indeed, since parents and educators are the most regularly and frequently present persons in children's microsystem, they are effective on preschool children's STEM learning through the learning opportunities they offered to children (McClure et al., 2017). Therefore, in an early childhood classroom, a successful curriculum innovation compatible with the engineering content requires the engagement of multiple stakeholders in the process (Bagiati & Evangelou, 2015). In other words, the upbringing of a generation that understands what the disciplines of engineering and technology are and why it is important for both humans and the world requires the energies, creativity, and talents of communities of practice, including teachers, parents, and children (Cunningham, 2009). Therefore, as in all other disciplines, the involvement of parents in the educational process has a great importance for engineering education initiatives addressing preschool children (Bagiati & Evangelou, 2015; Dorie & Cardella, 2014; Smetana et al., 2012).

As the people who purchase toys for their children, read them books, take them on trips, interact with them through play and talk, and function as an agent of their informal learning experiences, parents are one of the most substantial components of their children's engineering education (Doire & Cardella, 2014). Parents can begin to lay the foundations for engineering education from the child's early age in order to help their children to build a strong foundation for their subsequent learning. A preschool teacher may design learning experiences which stimulate children's curiosity and promote their thinking skills. Moreover, s/he may seek for opportunities to be models for children by employing problem-solving skills in their day-to-day work, and thus they create a classroom setting that encourages and nurtures preschool children as emergent engineers and young problem-solvers (Stone-MacDonald et al., 2015). On the other hand, children continue to learn outside of the school setting by means of a variety of external and internal sources. These informal learning experiences occurring outside of the school setting can be as effective as classroom teaching (Dorie & Cardella, 2014). For this reason, it is possible to obtain positive results when engineering education provided to children in the classroom environment is supported by their parents in out-of-school settings. Indeed, parents can motivate their children's engineering curiosity, provide their children with experience in engineering concepts and competences, and engineer parents can be role models for their children (Dorie, Jones, Pollock, & Cardella, 2014). On the other hand, research revealed that engineering was perceived as more intimidating and unachievable than the other fields of STEM by educators and parents (Stone-MacDonald et al., 2015). In fact, teachers and parents who do not have an engineering background perceive engineering generally as a content requiring in-depth specialization. This may be related to the availability of limited source for engineering education for parents and educators of young children (Bagiati et al., 2010; Bagiati & Evangelou, 2018). In fact, contrary to the disciplines of science and mathematics which have a deep-rooted history in early childhood curricula, engineering is a novel knowledge base. Therefore, a great number of fundamental questions, such as how engineering should be taught in early years (in both the school and home environment) or which types of materials and curriculums should be used remain unanswered (Katehi, Pearson, & Feder, 2009). To find out the responses of such questions, there is a need for research-based engineering curricula developed for the early childhood period (English, 2018). In addition, such curriculum innovations should give parents, teachers, and children the opportunity to experience and learn engineering and STEM together (Akgündüz, Ertepınar, Ger, Türk, 2018; McClure et al., 2017). In the current study, a developmentally appropriate STEM-based engineering design curriculum for parental involvement (PI) in ECE (EDCPI) was designed and developed to meet this need.

1.1 Purpose of the Study

The purpose of the current study was twofold. First, this study aimed to design and develop an engineering design curriculum based on PI to provide preschool children with engineering and STEM-related learnings and to explore the basic design principles in designing and developing such a curriculum. In this context, this study aims to identify the main characteristics of the designed and developed curriculum and the barriers to and facilitators of the curriculum from the participants' perspectives. Secondly, this study aimed to investigate the possible contributions of the developed curriculum to preschool children, parents, and teachers. In line with these aims, some research questions were investigated:

1) How can a STEM-based engineering design curriculum aimed at providing preschool children and their parents with engineering-related learnings be designed and developed?

   a) What are the main characteristics of an effective STEM-based engineering design curriculum that allows preschool children to learn by experiencing engineering with their parents?
   b) What are the facilitators of EDCPI?
   c) What are the barriers to EDCPI?

2) What are the possible contributions of EDCPI to its target users?

   a) What are the contributions of EDCPI to preschool children?
   b) What are the contributions of EDCPI to parents?
   c) What are the contributions of EDCPI to teachers?

1.2 Significance of the Study

The current study aimed to design, implement, and develop an effective and practical STEM-based engineering design curriculum for PI in ECE (EDCPI). The study also aimed to investigate the preschool children's engineering-oriented learnings throughout this curriculum. This research is thought to be significant in a few ways. These aspects are described in the following paragraphs.

First, it is thought that this study will contribute to both national and international literature for early engineering education (EEE). Indeed, looking at published studies in the pre-college engineering education field, we can see that engineering education has continued to make progress in both elementary (Cunningham, Lachapelle, & Davis, 2018) and secondary schools (NGSS Lead States, 2013; Katehi et al., 2009) around the world. Considering the importance of introducing engineering to children at an early age (Bagiati et al. 2010), in recent years, researchers have also directed their attention to bringing engineering into ECE environments (Bagiati & Evangelou, 2018; Blank & Lynch, 2018; Cunningham et al., 2018; Dorie, Cardella, & Svarovsky, 2014; Lippard, Riley, & Lamm, 2018; Van Meeteren, 2018). Despite these efforts, a limited number of studies on preschool children's engineering education exist in the literature (Bagiati, 2011; Bagiati & Evangelou, 2016; Christenson & James, 2015; Evangelou, Dobbs-Oates, Bagiati, Lians, & Young Choi, 2010; Lottero-Purdue et al., 2016; Van Meeteren & Zan, 2010; Pantoya, Hunt, & Aguirre-Munoz, 2015; Torres-

Crespo et al., 2014). Similarly, in the national literature, only a few studies focus on the preschoolers' engineering education (Ata-Aktürk & Demircan, 2018a; Ata-Aktürk & Demircan, 2018b). This study, which serves as an example of how engineering education might be implemented in preschool classes, is expected to contribute to the relevant literature and provide a resource for future researchers working in this field.

In this limited literature, findings of existing studies have revealed that engineering is a natural part of preschool children's everyday activities and that EEE promises to contribute to the learning of preschoolers in all STEM disciplines (Bagiati, 2011; Lottero-Purdue et al., 2016). Research has also revealed that parents play a critical role in their children's awareness of and interests in engineering (Dorie, Jones, Pollock, & Cardella, 2014; Yun, Cardella, Purzer, Hsu, & Chae, 2010). In fact, understanding that PI contributes to the interest of young children in engineering is key to appreciating the developmental priorities of the interest in engineering (Bagiati, Evangelou, & Dobbs-Oates, 2011). In this regard, studies have been carried out that draw parents and their children together through robotics and engineering activities (Bers, 2007; Gunning, Marrero, & Morell, 2016; Smetana et al., 2012) and examine their interactions during these activities (Dorie et al., 2014). Similarly, some organizations like STEM career nights and family engineering days are carried out to involve parents in their children's engineering education (Peterson, 2017; Smetana et al., 2012). All these efforts are valuable in terms of improving awareness towards engineering and allowing parents and children not only to have fun, but also to learn, explore, and create together. On the other hand, due to their limited exposure to engineering content, preschool teachers might have discomfort in implementing such engineering activities or procedure (Bagiati, 2011). In fact, engineering is new educational content for preschool teachers. Therefore, it may be difficult for them to know what to teach, what to look for and what to ask in an engineering activity (Cunningham et al., 2018). The lack of an effective curriculum model may hinder teachers from conducting parent-involved engineering practices in ECE settings. However, a comprehensive curriculum, both culturally and developmentally appropriate may reduce preschool teachers' anxiety to integrate engineering into a range of ECE environments (English, 2018). Such a curriculum that provides a clear educational process, an education philosophy, learning objectives, and relevant assessment tools can provide teachers with a framework for engineering education in the preschool period (Bagiati, 2011). This curriculum provides teachers with research-based learning objectives and indicators for early childhood engineering. Thus, in addition to the exemplary activities presented in this curriculum, teachers may derive similar engineering activities for PI in their classrooms with the guidance of these objectives and indicators. On the other hand, to the researcher's knowledge, a research-based early engineering curriculum, which brings together children, parents, and teachers who are the stakeholders of the educational process have not been developed yet. Based on the view that engineering education can also be carried out as a PI activity in schools, this study aims to develop a research-based and classroom-tested engineering design curriculum for PI in ECE. In this respect, this study addresses the existing gap in the early engineering literature and practice and suggests an alternative way to PI in education.

Thirdly, this study is thought to be significant because it might serve as a resource that can help preschool teachers to support their students' engineering education. Even though researchers and educators accept that to be exposed to engineering in early years is very important and early childhood educators should become knowledgeable in the discipline of engineering, an inadequate number of sources for engineering education are present for parents and educators of young children (Bagiati et al., 2010; Dorie et al., 2014). In this regard, providing parents and teachers with an opportunity to focus on informal learning experiences is an important way of learning together for children, teachers, and parents. Furthermore, involving parents in their children's engineering education gives schools the opportunity to motivate children to obtain scientific and technological literacy, which is important to be successful and competitive in the 21st century's labor force (Smetana et al., 2012). It was also expected that the current study would improve preschool teachers' subject matter knowledge in engineering education and such a curriculum would be beneficial for preschool teachers who did not have any background or knowledge about integrating engineering into their teaching (Custer & Daugherty, 2009). Hence, it was expected that this study would be beneficial for teachers in integrating engineering design experiences into their teaching practices and to strengthen children's learning and problem-solving skills in the STEM disciplines.

Another aspect which makes this study significant was that the study conveyed the message to parents that they had a say in the development of content for their children's education, that they were valued in educational environments and that their support was needed in the education process. Involving such a PI activity might make parents more comfortable in the school environment and make them feel more confident in the ability to collaborate with their children in engineering design projects, and to take steps to develop their own education about science and engineering (Epstein, 2010). Indeed, as Smetana et al. (2012) emphasized, parents may need suggestions about how they can continue to support their children's curiosity in engineering and science in environments outside of the school setting. By means of engineering design activities taking place in the curriculum, while children learn the steps of scientific learning, parents might find the answer to the question of how they could guide their children's learning in science and engineering by means of first-hand experiences. In order to guide preschool children's engineering learning experiences, parents and teachers should have an understanding of engineering and should know how to transform daily life experiences into teachable moments for children. This study might make teachers and parents more aware of the importance of engineering in preschool children's discoveries and learnings in STEM disciplines and about the way to guide children's questions and curiosity.

On the other hand, studies focusing on children's knowledge about engineering revealed that some children had almost no knowledge about engineering or held misconceptions about what engineers do (Ata-Aktürk & Demircan, 2018; Knight & Cunningham, 2004; Pantoya et al., 2015). For instance, when children were asked what engineers were doing, many said that the engineers were driving trains (Pantoya et al., 2015), or they considered engineers as individuals who were fixing vehicles (car mechanics) or building structures such as bridges (construction workers) (Knight & Cunningham, 2004). However, it is important that when preschool children design and construct block buildings, they need to be aware of the fact that they are engaging in the same work as that carried out by engineers and architects (Moomav, 2013). The misconceptions which children have about engineering can be changed by helping them recognize examples of engineering existent in their daily life, their school and home, and by providing children and their parents with opportunities to implement the EDP in various contexts (Smetana et al., 2012). The current study allowed preschool children to experience engineering design activities with the involvement of their parents and tried to improve their learning in engineering and other STEM fields by means of a STEM-based engineering design curriculum.

Briefly, this study employed the design-based research methodology in a real classroom setting to develop a research-based curriculum characterized by the involvement of parents in their children's education process and to propose a set of engineering design activities supporting that developmental process. Therefore, this study is expected to shed light on the key elements and practices of an effective engineering education in early childhood. In this regard, it is believed that this study will serve as a bridge between theoretical approach and implementation and provide practical outcomes.

1.3 Definition of Important Terms

Early Childhood Education (ECE): Education and childcare services provided for children from birth to eight years (Bredekamp, 2016, p. 4). In some sources, ECE is also defined as the process that the child undergoes from her mother's pregnancy to the third grade in the primary school (Turkish Industrialists' and Businessmen's Association [TÜSİAD], 2005).

Kindergarten Children: The kindergarten which constitutes a bridge between preschool education and primary education is the first year of the formal school (Snow, 2012) and the kindergarten children consist of 5-6 years old (Bredekamp, 2016).

Preschool Children: Children aged 3 and 4 years are considered to be preschool children (Bredekamp, 2016; Schweinhart, 2017). Indeed, in Turkey, preschool education covers the education of children in the age group of 3 (children older than 36 months), 4 and 5-year-olds (children younger than 66 months) who are not required to attend compulsory primary education. Preschool education institutions can be established as independent preschools, as classrooms within the primary schools or as practice classrooms connected to other relevant educational institutions (MoNE, 2014). On the other hand, in Turkey, the preschool period covers children 36-72 months (MoNE, 2013). In the current study, the definition of Turkish MoNE was grounded on.

Parent**:** The parent(s) means person(s) who is responsible for the care of the child. This person can be the child's mother, father, foster-parents or any individual who is a member of the extended family (Epstein, 2011).

STEM Education: STEM education is an interdisciplinary approach to learning that removes the traditional barriers separating the four disciplines of science, technology, engineering, and mathematics and integrates them into real-world, rigorous, and relevant learning experiences for students (Vasquez, Sneider, & Comer, 2013, p. 4).

Engineering Design: The path following from the problem to the solution, including a definition of a human problem, the search for possible solutions, the selection and planning of the most appropriate solution, the construction and testing of a model, the improvement of the model, and communication regarding the solution (NGSS, 2013; NRC, 2012). In this study, the steps (think about it, try it, fix it, and share it) determined by Stone-MacDonald et al. (2015) will be used as early childhood engineering design phases.

Design-Based Research: "the study of learning in context through the systematic design and study of instructional strategies and tools" (Design-Based Research Collective, 2003, p.5).

Intervention**:** In the current study, the term the intervention was used to define all the acts carried out during the study which might be effective on the participants. In this regard, the intervention consisted of the training provided to parent and teachers and the implementation of the curriculum.

Implementation**:** In this design-based study, after the expert appraisal, the second and third prototypes of developed curriculum were implemented in two different iterations (micro-evaluation and try-out) with different samples of target users. Therefore, throughout the study, the term implementation was used to signify the micro-evaluation and/or try-out studies in which the different two prototypes of the curriculum was implemented.

CHAPTER 2

LITERATURE REVIEW

This chapter presenting the review of the relevant literature is organized into four main sections in line with the focus of the study. In the first section, theoretical background of the study is focused on. In this context, a review of the three main theories underlying the early engineering education (EEE) and parental involvement (PI) are introduced. In the second section, engineering related dimension of the study is focused on. In this context, a review of current research, the curricula and frameworks developed in the field of EEE are introduced. Existing early engineering standards and the place of Science, Technology, Engineering, and Mathematics (STEM) education and engineering in Turkish context are also presented in the second section to form a frame for the engineering design curriculum developed within the context of the current study. The next section is about the PI, which is another dimension of this study. In line with this, the importance of PI in early childhood, PI models, roadblocks for PI, the role of the parents in their children's engineering education and the need for a preschool engineering design curriculum for PI in ECE is clarified. The fourth section focuses on the literature on curriculum development. Curricular ideologies, curriculum development models and the curriculum framework utilized in this study are reviewed within this section. Finally, the relevant literature review is briefly summarized.

2.1 Theoretical Background of the Study

Engineering has a complicated and interdisciplinary nature. Similarly, the phenomenon of child development and learning is complex. Therefore, EEE should be approached from a multi-theoretical perspective (Lippard et al., 2018). This study takes its roots from three different theories which are constructionism, ecological systems theory, and sociocultural theory. First of all, this study based on constructionism, because, in the field of education, engineering design takes its roots from the "*Constructionism",* which is a learning theory proposed by Seymour Papert in 1980. Papert describes constructionism as:

> From constructivist theories of psychology, we take a view of learning as a reconstruction rather than as a transmission of knowledge. Then we extend the idea of manipulative materials to the idea that learning is most effective when part of an activity the learner experiences as constructing a meaningful product (Papert, 1986, p. 2).

Constructionism was inspired by Jean Piaget's (1896-1980) constructivism defending that learning occurs through the construction of new knowledge by interacting with objects in the environment. Similarly, constructionism defends that construction of new knowledge comes true by means of the construction of physical and manipulative tools such as blocks, beads, and robotics (Nugent, Barker, & Grandgenett, 2012). In this respect, the views of Papert and Piaget were parallel with each other. Both are constructivists who argue that children continuously construct and reconstruct their own knowledge and external realities based on their personal experience. Both believe that knowledge is a personal experience which is constructed, not just a commodity that is transmitted, encoded, stored and reapplied (Ackermann, 2001). However, the constructionism extends Piaget's constructivism theory by advocating that children can construct powerful ideas when rich learning environments and effective tools are provided to them (Stone-MacDonald et al., 2015). According to Piaget learning is a result of "the change in the behavior arising from experiences." Papert, on the other hand, argues that although learning takes place within the minds of the learner, if the learner is involved in an activity that makes sense for her/him and makes learning actual and sharable, learning occurs most reliably. This sharable construction may be a robot, or a musical composition, a poem, a speech or a new hypothesis (Martinez & Stager, 2013). Besides, Papert defends that electronic media adds a new dimension to the ways of thinking. According to constructionists, today's children are able to design their own objects which unite the mechanical and electronic (Bers, 2008). From this aspect, constructionism is a strong design tool to convert passive educational experiences to greatly appealing, thought-provoking, and educationally productive activities (Papert, 1993).

Constructionism suggests that learning occurs better when opportunities of designing, creating and building projects, which are individually and epistemologically meaningful, are provided to people. Projects are formed based upon learners' individual interests and the needs of the community. According to the constructionism, learning occurs best in a technologically rich, design-based learning environments in which children and adults come together. In such an environment, children experience learning by doing, exploring, programming and designing in a playful way (Bers, 2008). Such an educational environment can be constructed through engineering design, and in such an environment, the engineering design process (EDP) serves as a catalyst for children's learning (Brophy, Klein, Portsmore, & Rogers, 2008). Hence, constructionism was the main theoretical lens underlying this study which aims to design and develop an engineering design curriculum by which children, their teacher, and their parents come together to experience EDP.

This study is also structured around the view that learning can be supported by the involvement of parents who are their children's first teachers, in their children's education process. Therefore, this study also takes its roots from the theories underlying PI. One of these theories is Bronfenbrenner's *Ecological Systems Theory.* In the 1970s, by means of his innovative and effective argument, Urie Bronfenbrenner provided evidence to the importance of the parent-school partnership in child education and development. According to him, to completely comprehend human development we should move beyond the shallow one-to-one relation between the child and his/her immediate environments and caregivers (Bronfenbrenner, 1979). In line with this, in his ecological systems theory, Bronfenbrenner emphasizes that human development takes place in increasingly complex processes, especially at the early stages, due to the interaction between developing children and other people, objects and the symbols surrounding it. In other words, the child grows up in a complex system that is affected by the environment at different levels. Bronfenbrenner regards the environment as a system which consists of a set of nested layers. This system includes a greater circle in which children keep daily lives including the home, school and the neighborhood (Berk, 2013). He grouped all those structures influencing human development and education under four main titles and circles representing each title (see Figure 1). The person is at the center of these circles. According to him, the first circle which constitutes the immediate environment of the child is the *microsystem*. The microsystem specifies a pattern of activities, interpersonal relationships and social roles that have certain physical, social and symbolic characteristics that invite, accept or block long-term participation in a face-to-face environment in which the growing child lives (Bronfenbrenner, 1994, p.39).

The family is the most immediate and familiar microsystem for a child. Other microsystems involve the closest and familiar environments of the child, such as early childhood institutions, schools (Hayes et al., 2017), local community environments, and the persons and experiences within the scope of those settings (McClure et al., 2017). The second circle represents *mesosystem,* which contains the connections and processes occurring between two or more environments including the developing child. For instance, the linkage between the home and school or the school and the workplace. Indeed, a mesosystem means the system of microsystems. (Bronfenbrenner, 1994). The *exosystem,* which is the third circle, consists of social structures including the child, yet it can directly or indirectly influence him/her. For a child, the connection between the home and parent's workplace and for the parent, the connection between the school and their child's peer group can be examples of the exosystem. The *macrosystem,* which is the outermost cycle, includes cultural values, approaches, frames and models forming the setting where the child learns (McClure, et al., 2017). Lastly, the *chronosystem* means the effect of time on the child's development (Hayes et al., 2017).

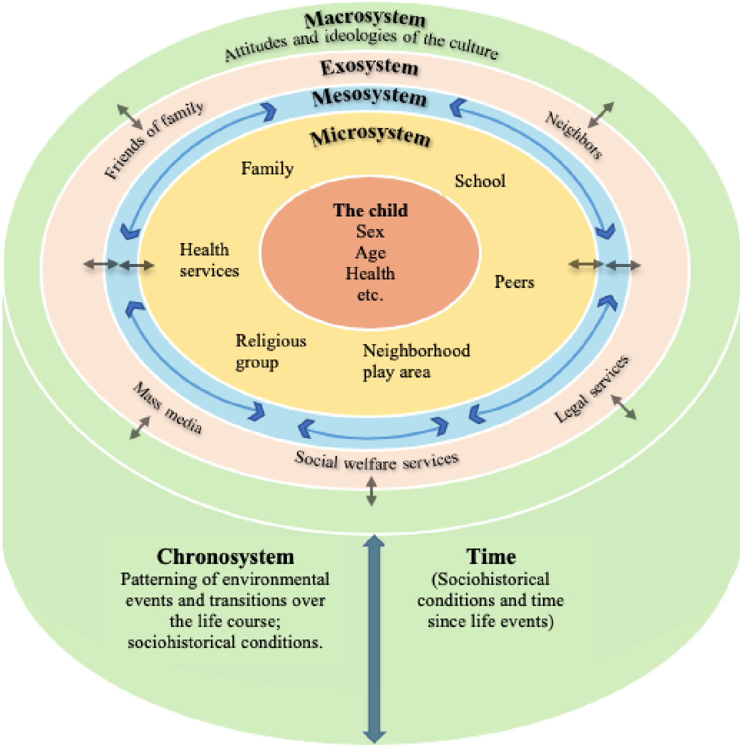

Figure 1 Bronfenbrenner's Ecological Theory of Development (adapted from Santrock, 2011, p. 29).

Bronfenbrenner defends that the environment is an ever-changing system rather than a static system which affect children in an only manner. Hence, some important developments, such as the birth of a sibling or the divorce of their parents, bring about new conditions that affect the development of the child (Berk, 2013). Moreover, the historical time of the change is effective on the development (Hayes et al., 2017). For instance, the birth of a new sibling does not have a similar effect on a two-year-old, and on a school-age child who has several relationships and activities outside the family (Berk, 2013).

As for the young children's education, the influence of multiple and interconnected environments and systems on children should be considered. In fact, children need the alignment and collaboration of all these components in order to reach their full potential in learning. In other words, in order to establish efficacious policies, policy makers need the understanding of the public, the collaboration of teachers, and the promotion of reliable research. On the other hand, researchers can produce effective studies by means of accessible funds, the help and assistance of teachers in the classroom, and the point of view of the political systems to which their studies are applied. Similarly, for effective professional development, teachers need as much education and resources as possible, along with support from their institutions and PI. Parents who are a significant component of the child's immediate surroundings, and thus the child's microsystem, can contribute to the learning of the child at home or elsewhere with relevant activities (McClure et al., 2017).

Another main theory constituting the theoretical frame of this study is the *Sociocultural Theory of Development*. As in Bronfenbrenner's ecological system theory, the sociocultural theory of development proposed by Lev Vygotsky (1896-1934) defends that the child learns through her/his interaction with other people around him/her. Vygotsky highlights how the social environment and culture guide the cognitive development of children (Santrock, 2011). His emphasis on the vital importance of the social context in the development and learning of an individual also leads to the model of Bronfenbrenner's ecological systems (Parrish, 2014). Indeed, according to Vygotsky, the social context, which Bronfenbrenner defines (1977) as the systems including all components which surround the child and are influenced by the culture directly or indirectly, influence what and how we think (Bodrova & Leong, 2013). According to him, we are the products of our social and cultural environment, therefore, understanding a child depends on understanding the social and cultural conditions in which the child develops (Berk & Winsler, 1995). This social context has a critical role in the learning and the social interactions change the learning experiences (Schunk, 2011). In this regard, Vygotsky considers cognitive development as a social-mediated process in which the child needs to the support of the adults or the expert peers to struggle with the challenges (Berk, 2013). Indeed, the child firstly develops new capacities while s/he is collaborating with an adult or the peers who are more competent, and then internalizes it (Berk & Winsler, 1995). At that point, there is a "…distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p.86). Vygotsky calls this distance as *zone of proximal development* (ZPD). In the ZPD, the lower limit refers the level of skills which the child can carry out independently while the upper limit is the level of additional responsibilities undertaken by the child under the guidance of a tutorial (Santrock, 2011) (see Figure 2). Vygotsky defends that the purpose of the education is to provide the child with the experience in her/his own ZPD and the challenging activities s/he can accomplish under the guidance of an adult. In this regard, adults undertake the responsibility for ensuring that learning of the child is maximized through actively guiding her/him throughout the development process (Berk & Winsler, 1995). According to him, what the child can accomplish by cooperating with an adult or his peers today is at the same time that s/he can succeed independently tomorrow. Similarly, what the child can achieve today by applying for maximum help is what s/he can accomplish tomorrow with minimal help (Bodrova & Leong, 2013).

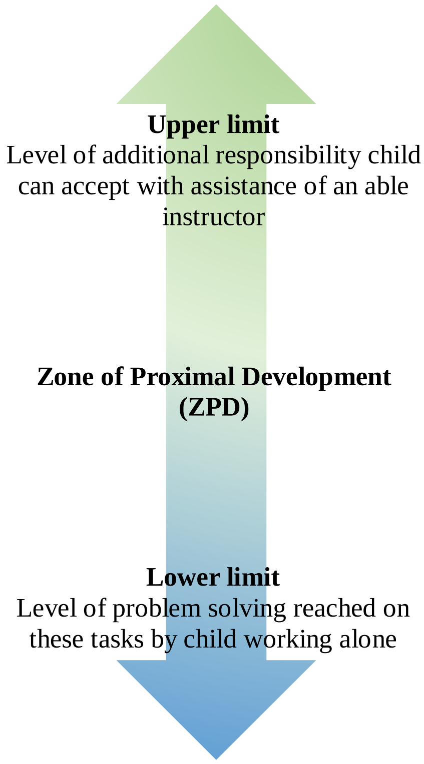

Figure 2 The ZPD introduced by Vygotsky (adapted from Santrock, 2011, p. 191)

To sum up, this study was formed in the light of three main theories of cognitive and social development. By considering constructionism all the activities within the EDCPI engage preschool children and their parents in constructing solutions to the problems meaningful to them through physical materials and hands-on experiences. Based on the ecological systems theory and sociocultural theory, EDCPI emphasizes the inclusion of the parents in their children's problem-solving process. In this respect, the activities were intentionally designed beyond the difficulty that the children can solve alone. In this way, the child can develop his/her skills to perform new tasks with the careful guidance of his/her parents and then perform these tasks independently.

After the underlying theoretical background of the study, in the following sections of this literature review, STEM education, engineering, EDP, the developments have taken place in K-12 engineering education, and the common features of preschool children with the engineers are explained.

2.2 STEM Education

In today's world, as a result of globalization, countries have begun to place an increasing emphasis on economic success, advances in technology and the leadership in the fields of defense industry. Moreover, the developments in the world and the reduction in available resources have brought about an increasing competition for countries in terms of industrial and technological development. Hence, the countries have felt themselves obligated to take a reformer step in their educational policies in order to deal with this competition (Akgündüz et al., 2015). Indeed, as most of the leaders emphasize, more innovation created by people open the door of a long-continued economic health and even a complete economic recovery (Çorlu, 2012). STEM education aiming at growing innovative and productive children by providing them STEM disciplines from an interdisciplinary and holistic viewpoint (MoNE, 2016; Urban & Falvo, 2016) is at the core of this educational reform movement (National Research Council [NRC], 2011).

STEM is an educational approach that emerged in the United States and aims to prepare children for the global economy of the current century (Yakman & Lee, 2012). The concept of STEM education, which is still maturing, can be considered as a search for a different and contemporary educational paradigm, covering informal and formal education efforts focused on Science, Technology, Engineering, and Mathematics (Çakıroğlu, 2018). STEM education grounds on the integration of disciplines (Yamada, 2018) and covers the entire educational levels from preschool to higher education (Akgündüz et al., 2015). This integration is provided by the combination of two or more STEM disciplines (Kelley & Knowles, 2016; Moomaw, 2012) into one unit, lesson, or activity which is based on connections among the subjects and real-life problems (Moore et al., 2014).

STEM is no longer just a term in the international sense, it has become an educational movement for the education system of many countries (Li, 2018) such as United States, Japan, China, Korea, Singapore and Germany (Gonzales & Kuenzi, 2012; Yamada, 2018; Jho, Hong, & Song, 2016). As one of the terms of STEM, Science deals with nurturing curiosity, experimenting, investigating, seeking answers and daily life experiences while Mathematics deals with searching for patterns and relationships by relying on fundamental structures and relationships. Technology, another STEM discipline, refers to tools from digital materials like computers, mobile phones or cameras to everyday stuff like a zipper, a magnifying glass or even a crayon (Sharapan, 2012). Lastly, Engineering, which has recently received great extent attention as a fundamental component in STEM education (Park, Park, & Bates, 2018), focuses on solving problems, designing or redesigning objects and systems by considering needs and expectations of the society (Smetana et al., 2012).

2.3 The "E" in the STEM Acronym: What is Engineering?

Approaches to comprehension and the possible advantages of engineering education in K-12 classrooms are based on having a knowledge of engineering itself. The word 'engineer' is derived from "*ingeniare"*, a Medieval Latin verb which means designing or devising. In turn, the word of "*ingeniare"* is derived from *"ingenium"* which means smart invention. Hence, with a short definition, engineering is "the process of designing the human-made world" (Katehi et al., 2009, p.27).

Engineering is associated with human beings' attempts to transform the world based upon their knowledge and observations in order to reconstruct the environment where they live with the aim of improving their lives (Bagiati & Evangelou, 2016). Engineering has played an important role in each phase of human history due to the tendency of people to design and build tools and other equipment. The role of engineering and engineers has widened and diversified from only military fortifications and machines to products which influence societies and everyday lives of people in terms of almost every aspect (Katehi et al., 2009). That is, our daily lives are surrounded by the outcomes of EDP. For instance, industrial, mechanical and electrical engineering serve as designing the structures, systems and engines, which fill our homes with such things as furniture, televisions, music players, household appliances, computers and heating and cooling systems (Stone-MacDonald et al., 2015). The manufacturing processes used to develop chemicals and drugs in the chemical and pharmaceutical industries (e.g. shampoo, toothpaste, plastics, detergent and medicines), as well as the procedures used to bring the contents together are designed by the engineers (Katehi et al., 2009; Stone-MacDonald et al., 2015). As another area of engineering, civil and environmental engineering engages in the construction of cities and towns' infrastructures, such as clean water, roads, traffic lights, bridges, tunnels and electricity delivery. Lastly, computer engineers produce computer technology, which nowadays influences almost every arena of everyday life (Stone-MacDonald et al., 2015). On the other hand, the construction of all these artifacts is usually not done by engineers. Engineers are those who develop plans and instructions on how to construct artifacts (Katehi et al., 2009).

Engineering requires the application of cognitive processes and STEM subject matter knowledge in designing, analyzing, and troubleshooting complex systems to meet the needs of society. This is exactly what engineers do in the development of new vehicles (e.g. cars, electronics), processes (e.g. food processing, airport planning, manufacturing), and infrastructures (e.g. energy distribution, waste management, and transportation), and in the improvement of existing ones (Brophy et al., p. 371). Indeed, all the above-mentioned technologies are designed by engineers with an in-depth knowledge of mathematics and science as well as their ability to use their imagination and creativity in their designs (Smetana et al., 2012). Hence, engineering is a glue for keeping science and math together and presenting a meaningful context (Pantoya et al., 2015). Similarly, since the nature of engineering design problems requires knowledge of mathematics and science, engineering serves as a natural connector in the integration of STEM disciplines into the classroom (Moore et al., 2014). Although it is not possible to deal with all STEM content, especially the theoretical ones with design-based instruction, engineering design allows children to gain experience in STEM disciplines and to acquire new knowledge and skills in these areas (Guzey, Tank, Wang, Roehrig, & Moore, 2014; Kelley & Knowles, 2016).

2.3.1 Engineering Design Process

Design is used as a common word in order to define the works of graphic artists, fashion designers, landscape architects and flower arrangers. However, in the engineering context, design has a specific meaning (Katehi et al., 2009). In engineering, design is about meeting human needs and demands. Engineering design refers to a repetitive process which starts with identifying a problem and ends with reaching a solution, taking into consideration the determined constraints and corresponding conditions for the demanded performance. Indeed, engineers consistently formulate and test their hypotheses regarding the optimal solution of the problem they are trying to address (Stone-MacDonald et al., 2015).

Engineering is not just a process of designing new technologies. It also includes fabrication, operation, monitoring, and maintenance of these designed technologies. However, from the perspective of teaching and learning, engineering refers to the iterative cycle of the design process, which allows the implementation of scientific knowledge and engineering practices in the classroom environment to a great extent (NRC, 2012). The EDP is the main approach of engineers to problem-solving and is a systematic process including many diverse practices from the identification of a problem to the determination of solutions (NRC, 2012). Since there is no single, correct solution for engineering design problems, EDP includes multiple acceptable solutions (NRC, 2010). In their design process, engineers are concerned with many constraints that shape the conditions under which the problem-solving process takes place. These constraints may be social, physical, political, economic, ethical, or related to space, time, money, size or weight (NRC, 2012).

While not all engineers follow the same steps in the design process, some steps are fundamental. The EDP cycle usually begins with the identification of a need or problem and continues with being an investigation of this need or problem. During this process, the current situation of the problem and the current solutions are examined, other options are explored through the internet, library, etc. Afterward, the engineer brainstorms on new ideas about how to sort out the problem. S/he articulate and refines possible solution ideas. In the next step, the engineer identifies the best solution which meets the need or solves the problem. Then, s/he creates a two or three-dimensional model or prototype and tests his/her solution in terms of whether it works and meets the constraints. In the next step, the engineer discusses with the colleagues about how the solution best meets the problem and its societal effect and tradeoffs. In the final step, the engineer improves the solution based on the knowledge acquired during the tests and discussions (Massachusetts Department of Education, 2006) (see Figure 3). The process may end up with a three-dimensional product, such as vehicles or water filters, with two-dimensional products such as drawings or graphics or with digital products such as computer software (Stone-MacDonald et al., 2015).

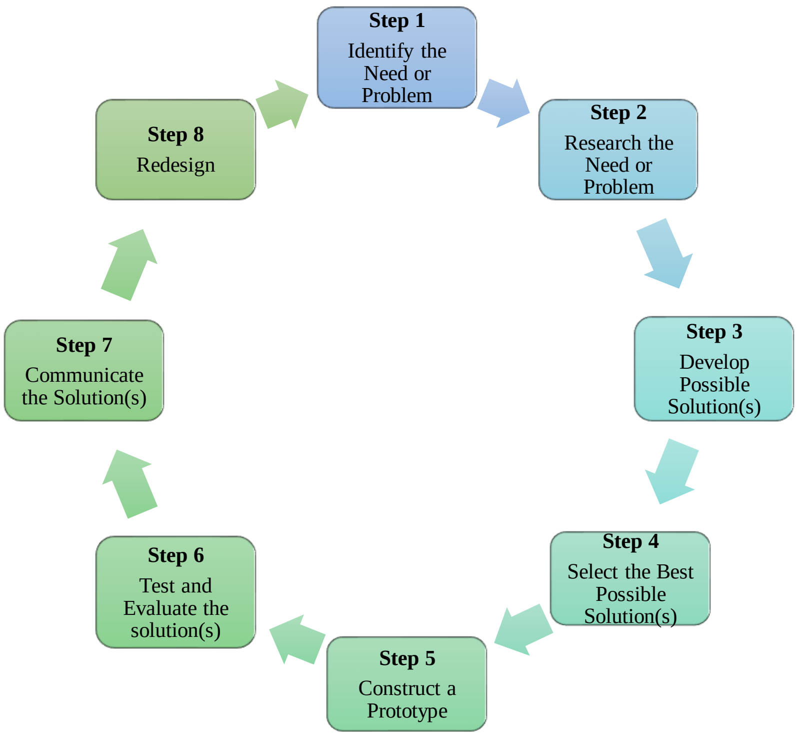

Figure 3 Steps of the EDP (adapted from Massachusetts Department of Education, 2006, p. 84).

Since, in professional engineering, the process differs according to the discipline and the project, it is not possible to talk about a single EDP (Berland, Steingut, & Ko, 2014). Specific departments of engineering (e.g. electrical, mechanical, environmental, chemical) have specific content knowledge, however, all of them use the EDP at diverse degrees in their problem-solving approaches. The prevalent existence of the engineering design in educational curriculums prepared for K-12 classrooms is related to the fact that EDP is a universal ingredient of all the departments of engineering (Portsmore, 2009) and also the core of the engineering education in K-12 classrooms (Hynes et al., 2011).

2.3.2 The Rise of K-12 Engineering Education

At today's society where people become increasingly dependent on engineering and technology, it is very important to educate children about the meaning of engineering and technology and their value for the society and the world (Cunningham, 2009). Indeed, engineering education is an area of research that enquires teaching and learning processes in engineering curricula. It aims to educate young thinkers with processes and practices to solve problems (Mann & Hrelja, 2013). In fact, the skills gained by means of main practices of engineering activities enable children to better comprehend how scientific knowledge is produced and how engineering solutions develop. In this way, it will be possible to raise children who use scientific knowledge more critically (NRC, 2012).

Over the last two decades, engineering education of elementary and secondary school children has become a global focus of interest (Purzer & Douglas, 2018). The concern about the quality, quantity and diversity of future engineering skills lies at the heart of this interest and the idea of integrating engineering education into all levels of education from kindergarten to college. Indeed, the expanding global utilization increased the developments in technology and growth in industry substantially. This development of enabling technologies has made it compulsory for industries to be more flexible and adaptive in order to be involved in competition. For this reason, the industry needed a workforce that was equally agile in adapting to changing conditions and thus could use new existing technologies and produce its own innovations. This rapid development in technology means that students in higher education must be educated differently from preschool to the 12th grade in order to be ready to pass to the undergraduate institutions working to provide a different pool of skills in the STEM areas (Brophy et al., 2008). In line with this, some attempts have begun to form a frame for engineering education in K-12 classrooms (see Table 1).

Although all these developed standards and frameworks did not include preschool period, it has guided the contents of preschool children's engineering education. Similarly,

Table 1

Important documents in development of K-12 engineering education

Document	***Developer(s)***	***Date***	***Aim***	***Contributions to the field***
Engineering in K-12 Education: Understanding the Status and Improving the Prospects	The "Committee on K-12 Engineering Education" established by NRC and National Academy of Engineering (NAE)	2009	Identifing the nature and scope of current efforts of K-12 schools to teach engineering	• Initiated an analysis of the existing engineering curriculum in K-12 schools; carried out a literature review about the conceptual learning areas regarding to engineering and the development of engineering skills and gathered information about several pre-college engineering programs used in K-12 grades in other countries • Formed a frame of existing literature and practices on engineering-related concepts and skills and general principles and influence of engineering education in K-12 classrooms. • Emphasized that in K-12 classrooms, unlike mathematics, science and technology education, the established learning standards for engineering education were not yet available. • Three general principles to guide the K-12 engineering education. According to the these principles, in engineering experiences provided to K-12 children: ○ engineering design should be emphasized ○ important and developmentally appropriate knowledge and skills in mathematics, science, and technology should be incorporated ○ engineerign habits of minds should be promoted (Katehi et al., 2009, pp. 151-152) ○ systems thinking ○ creativity ○ optimism ○ collaboration ○ communication ○ attention to ethical considerations
Standards for K-12 Engineering Education	The "Committee on Standards for K-12 Engineering Education" established by NRC	2010	Evaluating the potential importance and feasibility of stand-alone standards for the K-12 engineering education in the United States.	• Arrived a decision about that "although it is theoretically possible to develop standards for K–12 engineering education, it would be extremely difficult to ensure their usefulness and effective implementation" (NRC, 2010, p. 1). • There is a lack of sufficient experience in engineering education in K-12 schools, the lack of qualified K-12 teachers to provide engineering education to their students, the lack of findings on the impact of standard-based instruction on children's learning in other STEM areas. • K-12 curriculum is already full of other disciplines with predetermined learning objectives and that there are significant obstacles to the determination of independent standards in completely new content, such as engineering in such a curriculum. • Rather than setting such standards, engineering learning objectives could be integrated into the existing standards of mathematics, science, and technology. • Core ideas (concepts, skills, and habits of minds) that are convenient for K-12 students should be defined (NRC, 2010).

Table 1

(continued)

Document	***Developer(s)***	***Date***	***Aim***	***Contributions to the field***
A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas	NRC	2012	Making certain that all K-12 students know the value of strength and wonder of science and have enough science knowledge to be involved in debates on associated issues.	• In order to provide students with meaningful learning in the fields of science and engineering, these three dimensions should be included in the various stages of the educational process, from the determination of standards to evaluation, from curriculum to instruction (NRC, 2012, p.2): • Scientific and engineering practices • Crosscutting concepts • Disciplinary core ideas • Students of K-12 science and engineering education should be built around these three dimensions. • Set light to a large number of new attempts to develop engineering curriculums and standards in K-12 engineering education (e.g. NGSS).
Next Generation Science Standards (NGSS): For States, By States	Cooperation of the National Academy of Sciences (NAS), NAE, the NRC and the National Academies Press (NAP)	2013	Providing one-line standards in science and engineering education for the use of teachers and curriculum developers.	• Includes performance expectations in order to put the vision of NRC's framework into practice. These performance expectations represent what children must do to exhibit proficiency in science and engineering and some learning goals appropriate with the framework (NGSS Lead States, 2013). • Offers only engineering design-related practices and ideas reflecting three dimensions of the NRC Framework and progress in each class level, rather than a whole set of standards for K-12 engineering education.
A Framework for Quality K-12 Engineering Education	Moore et al.	2014	Clearly and concisely defining the key components of the qualified K-12 engineering education, and thus satisfying the need for an extensive frame of core ideas in K-12 engineering education.	• Points out that engineering has increasingly gained status in educational settings, but the "core ideas" proposed in the 2009 NRC and the 2010 NRC reports for K-12 engineering education are not yet available. • The framework proposes 12 key indicators outlining quality engineering education; • Processes of design ○ Problem and background ○ Plan and implement ○ Test and evaluate • Apply Science, Engineering, and Mathematics • Engineering thinking • Conceptions of engineer and engineering • Engineering tools • Issues, solutions, and impacts • Ethics • Teamwork • Communication related to engineering

curricula developed in the light of these standards and frameworks were mostly concentrated on elementary and secondary school students, rather than preschoolers (e.g. *Engineering is Elementary*, *Engineering in Kindergarten*, *Engineering Everywhere*). However, research conducted with preschool children indicated that engineering is a part of preschool children's everyday activities (Lippard, Lamm, Tank, & Choi, 2019) and young children are gifted to be engaged in engineering when unique design possibilities have offered them (Purzer & Douglas, 2018). Indeed, as older children, preschoolers are also very skilled in producing, testing, and improving their own solutions to encountered problems (Bagiati, 2011; Pantoya et al., 2015; Stone-MacDonald et al., 2015; Sullivan, Elkin, & Bers, 2015). Therefore, researchers from the field of engineering education have directed their attention to engineering in preschool classrooms (Cunningham et al., 2018). In fact, some similar points between preschool children and engineers have persuaded researchers in the field to explore engineering in the preschool age group. These similar points are explained in the following subsection.

2.4 Engineering and Preschool Children

In the literature, preschool children are regarded as "*emergent engineers*" (Stone-MacDonald et al., 2015), "*young engineers*" (Van Meeteren & Zan, 2010) or "*natural engineers*" (Dorie et al., 2014) due to some of their characteristics reminding of engineers (see Figure 4). Firstly, engineers engage with solving problems, utilizing a wide variety of materials, designing and producing, and constructing things which work. It includes not only revealing how things are built and work, but also thinking about what can enable them to work better or differently. This way of exploration also constitutes the foundations of young children's scientific learning (Lippard, Lamm, Riley, & 2017). Indeed, preschoolers are quite curious about the names of objects, the ways in which various systems work, the causes of events and how they happen (Boston Children's Museum, 2013). Because of the curiosity they have, preschool children enjoy discovering, exploring, and questioning (Trundle, 2015). Therefore, exposing children to engineering education as of their early years holds promise for arousing their curiosity, fostering creativity, and arousing interest in following STEM careers in the future (NRC, 2012) (see Figure 4).

Secondly, preschool children are young engineers with regards to modifying the world to meet their own demands and needs (Ashbrook & Nellor, 2015; Van Meeteren & Zan, 2010). For instance, when preschoolers are playing in a sandbox or a mud puddle, sand or mud is too dry to do what they're trying to do, they try a variety of ways to move water from the source to the puddle (Ashbrook & Nellor, 2015). Indeed, they naturally encounter engineering concepts such as problem solving and design in their daily activities (Lippard et al., 2018). For example, pouring large sizes of toothpaste into the toothbrush may be a problem for a young child when brushing his/her teeth. A design that allows a small amount of toothpaste to be poured into the toothbrush can also be a solution for such a problem (Purzer & Douglas, 2018). In a similar vein, preschool classrooms also have plenty of opportunities for children to experience engineering thinking. These opportunities can arise when a paint color that children want to use finished and the children decide to mix the two colors to produce this color, or when children investigate the way a new toy works in the classroom (Lippard et al., 2018). In addition to solve the problems that they encounter with, preschool children have an innate desire to help other people and produce solutions to the problems. Indeed, when they encounter a character with a problem during their activities, preschool children are full of solution ideas and willing to help. They enjoy building towers using Legos and blocks or to making a bed from shoeboxes for their dolls. In this respect, engineering is intriguing and satisfactory for children due to its nature (Davis et al., 2017).

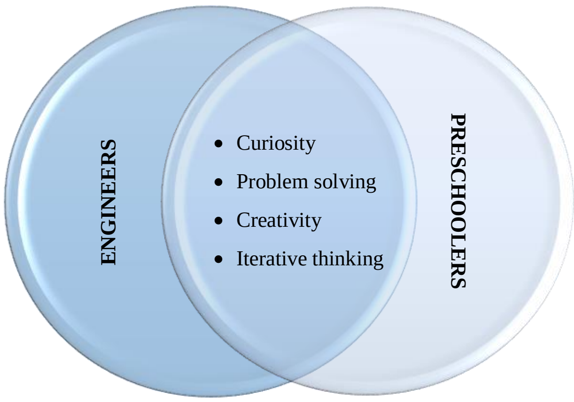

Figure 4 Common aspects of preschool children and professional engineers.

Thirdly, when designing technologies, processes, and systems constituting human-made world, engineers benefit from their knowledge in mathematics and science as well as their creativity (Davis et al., 2017). Indeed, while engineers produce effective solutions to problems, their creativity is at the forefront (Cropley, 2015). Creativity (Bagiati & Evangelou, 2016), one of the qualities desired in future engineers, is also an inherent characteristic of preschool children (Davis et al., 2017).

Finally, iterative thinking which involves trying a solution, testing this solution, learning from something that doesn't work well, and trying it again is the focus of engineers (Moore, Tank, & English, 2018). Similarly, young children are not afraid to experience failure to understand that their ideas do not work as they expected. They take what they have learned, review their thoughts, do not give up asking for new questions and trying again (Trundle, 2015). Therefore, when opportunities and support are given to them, young children can overcome even complex problems and produce possible solutions to these problems (Purzer & Douglas, 2018). All these common aspects make the preschool years a good starting point for engineering education (Bagiati et al., 2010; Elkin et al., 2018).

In addition to all these common characteristics, research indicates that engineering education is of capital importance to preschool children (Bagiati, 2011; Davis et al., 2017; English, 2018). The following subsection explains the reasons for the importance of engineering education in preschool years in the light of relevant literature.

2.4.1 Importance of Engineering Education for Preschool Children

As Evangelou (2007) stressed, engineering and early childhood education (ECE) are two fields overlapping with each other. The challenge is to protect and foster children's already existing qualifications over their educational course rather than to introduce engineering as an independent content in classrooms. Bers (2008) stressed that in ECE classrooms, "learning by doing" and "project-based learning" are two effective ways of learning. In order to carry out these two methods of learning, blocks have conventionally been utilized, but "learning by designing" arises as an alternative way. Indeed, the EDP composed of a synthesis of design-based and project-based learning processes (Bers, 2008) is an effective way of integrating engineering content into ECE (Stone-MacDonald et al., 2015).

In addition to be an effective alternative for project-based and design-based learning integration, it is possible to mention a wide variety of contributions of engineering education for young children (see Figure 5). The preschool period is the term when the brain development and synaptic connections, which constitute a strong ground for children's development in the fields of cognitive, language, motor, social and emotional, is most intense and fast. For this reason, children grow very rapidly especially in the first six years of life called the preschool period and they develop with surprising speed in these development areas (MoNE, 2013). Engaging in engineering from an early age supports this rapid development of preschool children in various areas. For instance, Major (2018) emphasizes that engineering design activities are great opportunities for preschool children to develop their gross and fine motor skills. In fact, during engineering design activities, children develop their motor skills while working with materials and creating their own designs during engineering design activities (Davis et al., 2017). Similarly, a building activity can be a good opportunity for preschool children to develop their gross and fine motor skills by moving large and weighty blocks or placing small blocks on top of each other. By the same token, the EDP contribute to the development of social and critical thinking skills by fostering collaboration and group work among children (Christenson & James, 2015). They develop socially while they are working collaboratively with others, sharing the materials and ideas and negotiating on these (Davis et al., 2017). For example, a four-year-old child notices that two-year-old children do not have steppers for jumping in their classroom. In her/his sketch s/he draws for this classroom, s/he may design an arch for two-year-old children and a stool for them to get up. Thus, s/he empathizes with others and realize their possible needs and problems (Blank & Lynch, 2018). To solve different design challenges, they cooperate with their peers, and in the small group or whole class discussions, they experience how to talk to their peers (Major, 2018). They grow up as members of a classroom community, and ultimately a member of a world community, who work in cooperation to produce solutions to the problems and stand up with each other. In a similar vein, they develop emotionally by coping with frustrations resulting from failures and setbacks and working without giving up for success (Davis et al., 2017). In addition, when engineering challenges are well designed, it offers many opportunities for children to negotiate ideas, to make statements about their choices, and to support their explanations with evidence. In this way, children's language development is supported, and they experience using simple engineering terms (Major, 2018).

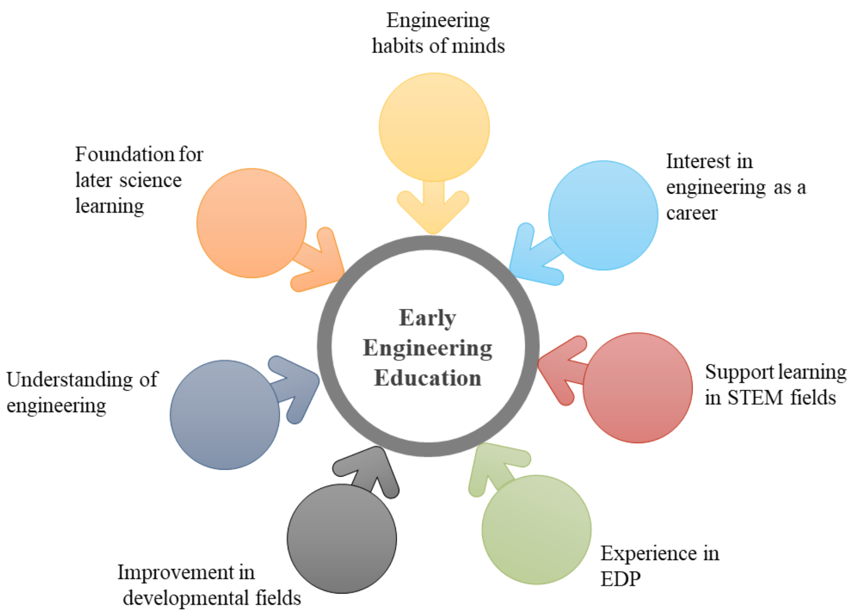

Figure 5 Possible contributions of engineering education to preschool children.

The National Association of Science Teachers (NSTA, 2014) states that being engaged with science and engineering practices at an early age can support the curiosity and enjoyment of preschool children to explore the world and laid the foundation for science learning in K-12 classrooms. This adventure of preschool children of recognizing the world through their experiences include interactions with not only the natural environment but also the human-made world (Moore et al., 2018). Indeed, children are surrounded by many technologies, from pencils to digital cameras and mobile phones. These technologies, which are engineering products, have permeated our lives (Bers, 2008). Engineering provides a way for children to get acquainted with technology not only as digital media but also with all elements of the human-made world (Moore et al., 2018). When preschool children experience engineering and interact with engineering products, they can begin to understand how important engineers and engineering products are in terms of facilitating and improving people's life (Boston Children’s Museum, 2013). As English (2018) stressed, from an early age, creating awareness of how engineering shapes our world, and nurturing this awareness will be a good start to the understanding of the contribution of engineering to our world. Moreover, experiencing the EDP may be effective on children’s knowledge about engineering as a profession and their engineering identity (Pantoya et al., 2015). Indeed, from the first years of their lives, exposing children to engineering can arouse interest in engineering as a career field and make them more prepared for engineering (Bagiati, Yoon, Evangelou, & Ngambeki, 2010).

Another possible contribution of engineering to preschool children is to give them an opportunity to experience the EDP and to offer meaningful and engaging contexts for scientific and technological literacy (Purzer & Douglas, 2018). In fact, children who experience the EDP learn to identify needs or problems, to take into consideration design possibilities, to plan, to prototype, to test and to try again (Honey & Kanter, 2013). These experiences gained by preschool children during EDP enable them to acquire many engineering concepts (Boston Children’s Museum, 2013) such as design, sketch, model, function (Bagiati & Evangelou, 2018). In addition to engineering concepts, some scientific concepts, such as density, energy (Raven, Husseini, & Çevik, 2018), and volume (Park et al., 2018) can be experienced by preschool children with engineering-based activities. Instead of developing a conceptual understanding (Raven et al., 2018), these activities focus on creating curiosity and enable children to experience these concepts in a concrete way.

As research revealed, engineering education may encourage learning, success (Katehi et al., 2009; Lachapelle & Cunningham, 2014), efficacy (DiFrancesca, Lee, & McIntyre 2014), and motivation (Morgan, Moon & Barraso, 2013) in other STEM disciplines. Indeed, engineering is closely connected with other disciplines, especially with mathematics and science (Hammack, 2016). Engineers use mathematical knowledge to define and analyze data and create models for testing design solutions. In a similar manner, to be able to solve problems, engineers must have relevant knowledge about science, specifically in the fields of physics, biology and chemistry. In turn, mathematicians and scientists utilize engineering products in their work (Hammack, 2016). The hands-on activities provided by engineering education, which try to address real-life problems, may increase the interest of children in science. In addition, it can enable children to consider science not only as interesting, but also as a subject which related to their lives and important for societal development (STEM Smart Brief, 2013). Since the engineering design approach provides a real-life context in the teaching of mathematical and scientific concepts and skills that are very abstract, it will be easier for children to learn and understand them when they are introduced to these concepts and skills during their engineering design activities (NAE, 2009). For example, a building play in which a child designs a space for toy horses using milk cans of different sizes can be an engineering activity that requires the application of science and math concepts to a real-world problem. In this example, the child may experience some important science concepts such as symmetry, balance, properties of materials and the effect of these properties on the structure. Similarly, s/he may utilize some concepts of mathematics such as one-to-one correspondence and measurement when creating columns of the identical height and adding a roof to her/his design. S/he may also take advantage of technology to preserve her/his design and to get other people’s views (Moomaw, 2013). Similarly, a building play that deals with an engineering problem, such as moving water from one place to another, can be a unique learning opportunity for the child to experience such concepts as conservation, measurement, and volume (Lippard et al., 2018).

Finally, engineering education helps preschool children to experience and develop their engineering habits of mind (EHM). The EHM which refer to the cognitive processes occurring during the engineering action includes some skills like collaboration, system thinking, communication, optimism, creativity, and ethical considerations (Dykstra & Meeteren, 2018). These habits of minds are also compatible with the 21st-century skills (e.g. communication, collaboration, creativity and innovation, critical thinking) that preschoolers need in their future educational levels and in their lives (Partnership of twenty-first Century Skills [P21], 2019). These habits are the developmental consequences of children's meaningful engagement in engineering concepts and activities and prepare children to learn throughout their academic careers and become involved in society as regardful and productive citizens (Lippard et al., 2018).

2.4.2 Current Research on Engineering Education of Preschool and Kindergarten Children

Engineering education in early childhood has begun to attract the attention of researchers in recent years, even if a limited number of studies on this subject are found in the relevant literature. The engineering and technology disciplines of STEM, which have been generally ignored in ECE (Sullivan & Bers, 2016), have started to attract more attention thanks to these efforts. Recent studies on engineering in early childhood are included in the relevant literature in the last ten years and promise the importance of EEE (Bagiati, et al., 2010; Bagiati & Evangelou, 2016; Bairaktarova, Evangelou, Bagiati, & Brophy, 2011; Cunningham et al., 2018; Evangelou, Dobbs-Oates, Bagiati, Liang, & Choi, 2010; Lippard et al., 2018; Lippard et al., 2018; Van Meeteren & Zan, 2010; Raven et al., 2018; Sullivan & Bers, 2018). However, engineering education has not been adequately represented in ECE, even if it is one of the areas with the highest applicability and relevance to real life, which children of all ages can experience in a successful and entertaining way (English, 2018).

The study carried out by Bagiati et al. (2010), provided evidence that in the early last decade, there was a limited number of sources of engineering education in early childhood. Researchers conducted a systematic analysis of open resources related to engineering education including Web sites and online documents (e.g. articles both in research journals and education magazines, and conference proceedings) developed for the use of early education teachers. Findings from the first search for online resources for PreK-12 indicated that a wide array of Web sites and online documents such as curricula, activity descriptions, and lesson plans were available for teachers. On the other hand, when the search was narrowed to PreK-3 level, a quite limited number of available open-access materials related to engineering education for teachers and parents were found.

The first studies conducted with preschool and kindergarten children in the engineering education field have focused on the engineering potential already existing in ECE environments and have created exemplary practices on how this potential can be translated into a learning opportunity for engineering education. For example, Van Meeteren and Zan (2010) thought it would be helpful to examine the possibilities that already exist in the preschool classroom environment rather than to add the EDP to the curriculum and provide children with complex and explicit design challenges. In this respect, researchers described the ways in which preschool teachers who adopt a constructivist approach create an environment in which children would head towards designing and building. In the study, teachers who noticed that children's interest in the block center decreased over time had added a ramps-and-pathways dimension (block units and objects with different properties) this center. In this way, they created an environment in which children would naturally orientate and design complex block structures. The children were then asked to choose an object and were asked how they could move this object. The materials chosen by children and their experience with these materials derived new questions (e.g. whether the object would act on a slope or how they would move, which object would go faster). This finding revealed that it is important for preschool children to discover their own questions and answers to these questions through their own experiences. Findings also indicated that such an experience made it possible for children to experience and reflect on concepts such as balance, force and motion, stability, properties of objects, number, and spatial reasoning.

The engineering thinking and behaviors that appeared naturally during children's play were another focus of the studies in the literature. In one of these studies, Lippard et al. (2018) investigated the engineering habits of minds naturally arising in preschool classrooms and characteristics of classrooms related to the occurrence of these habits. To that end, they conducted observations in nine different preschool classrooms through an observation tool developed by the researchers. Findings indicated that preschool children were engaged with five of the six engineering habits of mind in their daily activities, although not very often. Indeed, while creativity was never observed, system thinking was the most common observed habits of mind. Moreover, the block area was the classroom area in which engineering habits of mind were observed most frequently. On the other hand, when materials were presented that allow children to generate and solve problems, it was observed that the habits of the mind emerged not only in the block center but also in dramatic play center and art areas. In their another study, Lippard et al., (2017) conducted a literature review on engineering thinking in children aged three to five. Researchers considered these early years of life as a fundamental period for the development of engineering thinking, which meant goal-oriented thinking, addressing problems and making decisions within the presented constraints by benefiting from available materials or human capital. The literature review showed that preschool children show engineering thinking when they have hands-on experiences with materials. The study conducted by Evangelou, et al. (2010) represents an example of engineering thinking displayed by children during hands-on experiences. In the study, researchers investigated engineering thinking demonstrated by 4-5 aged children during the exploratory activities. The researchers created three diverse conditions (sketch, book, and tangible object) in each of which 13 artifacts such as pencil, camera, bellows, and compass were presented to children. The findings showed that the duration of the children's interaction with each artifact and their discussion about the artifacts were longer than the other two conditions in the tangible object condition, and in this condition, children showed more information and thought about the probable functions of the presented artifacts. The findings of these studies signify that it is important for children to have hands-on experience with tangible materials in EEE.

Another study that was carried out in order to discover spontaneously occurring examples of precursors to the engineering thinking and behaviors exhibited by preschool children during their free play is the study of Bairaktarova et al. (2011). In this study, structured (e.g. puzzle, rupture circuits), semi-structured (e.g. paints and paper) and open-ended (e.g. water, sand, cotton, grain) materials were included in the free play time, and 18 preschool children were observed during their free play with these materials. According to the findings, five different categories emerged that represent engineering-related play behaviors, including asking questions, explaining the ways things work and the things were built, construction, problem solving and evaluation of design. The most observed behavior was to asking questions/set goals, and the least observed was to explain how things work and were built. The findings also indicated that engineering-related behaviors are most often displayed in the settings where structured materials were provided. Besides, during their free play, children focused on completing the design by demonstrating some behaviors such as information gathering, problem solving and goal setting, rather than behaviors focused on evaluating the quality of their designs such as testing and prototyping.

Some researchers focused on children's building activities with blocks in order to observe preschool or kindergarten children's engineering thinking behaviors. In one of these studies, Bagiati and Evangelou (2016), based on the widespread use of the block play in preschool classroom settings and its similarity to the construction, which was a universal activity of mankind, observed preschool children's free play with blocks for four months. Researchers observed similarities between professional engineers and the ways preschool children approach an authentic construction task. The findings showed that during their free play with blocks, preschool children could identify the problem or need, building a structure for a particular purpose, testing their solutions, working in collaboration with each other and exchanging ideas about the function and appearance of their designs. In another study, Gold, Elicker, Choi, Anderson, and Brophy (2015) investigated gender and engineering play differences across three different play contexts: imagination playground (included large, moving, lightweight block-like materials, large loose parts); traditional playground (included outdoor playgrounds and fixed play materials such as slides, stairs, sandboxes, playhouses and swings); dramatic play area (included a wide variety of toys, dolls, action-figures, writing-drawing materials, cooking, and household materials). According to the findings, design and construction was the most observed play behaviors related to engineering in all three settings, while the least observed ones were solution/evaluation and technical vocabulary. According to the findings, there was no significant difference in the frequency of engineering behavior among girls and boys. However, the frequency of displaying engineering play differed in terms of different play contexts and it was observed that the context of large blocks provided more opportunities for engineering play.

The studies, which observe the natural existence of engineering in early childhood classes and the children's engineering related thinking and behaviors, have been followed in recent years by studies focusing on development of existing engineering knowledge of children through various interventions such as curriculum or activity development. In one of these studies, Lottero-Perdue et al. (2016) describe their experiences in how science and engineering thinking of kindergarten children can be guided through a structured and science-integrated engineering challenge. In the study, the kindergarten children experienced the EDP and were engaged in designing an egg package that prevented the broken egg from breaking when it fell. In another study, Malone et al. (2018) investigated how integrating dramatic inquiry, visual arts, dance and physical education into the engineering design challenges affected 4 to 8 aged children's conceptual knowledge of technology and engineering. For this purpose, they benefited from existing EiE units and incorporated arts into these units. Findings indicated that the intervention had a positive impact on the technology and engineering understanding of children aged 4 and 5 years. Indeed, both before and after the intervention, most of the 4-year-old children considered engineers as people who work with electronics, non-electronics, and environment. On the other hand, after the intervention there has been a decrease in the number of children who say that engineers engaged in repair and construction works. However, the findings of the study are different for children aged 5 years. Indeed, before the intervention, most of the 5-year-old considered as people who work with non-electronics and environment and repairing. On the other hand, after the intervention, children stated that the engineers were mostly working with construction, repair, electronics and non-electronics. The findings also show that children have some misconceptions about how engineers are repairers and plumber and that these misconceptions continue after the intervention. As in their understanding of engineering, the intervention positively affected children's understanding of technology. In fact, the correct classification of natural objects, electronic and non-electronic technology samples, both in the age group of 4 and 5-year-old children, increased after intervention.

In another study, Raven et al. (2018) aimed to introduce children aged 3 to 5 engineering practices and EDP and thus they designed three different learning activities by focusing on "Structure and Function". Before the implementation, researchers asked children what engineers do, and some of the children replied that the engineer was a type of teacher. During the last activity, children answered same question by saying that engineers built something, repaired things, discovered how to do things, designed various items and sometimes made mistakes. On the other hand, after the implementation, the children drew an engineer, and in most of the drawings, the engineers are depicted as men who built or worked. Findings also indicated that before the implementation children had some misconceptions about structure and function. Indeed, some children believed that the bigger the structure, the stronger it would be. At the end of the first activity, children were asked to examine the shapes of the bridges they built and to think about the shapes of the strongest structures. Moreover, many children argued that the bridges made of craft sticks were sturdier than those made with toothpicks, and they justified their thinking by saying that it was harder to break the sticks. This finding indicated that children who investigate, test, and make changes on their designs to meet the challenge in the best way had begun to understand the relationship between structure and properties of the matter.

Pantoya et al. (2015) conducted a study to investigate whether experiencing the EDP had an impact on children's engineering identities and their knowledge of engineering as a profession. In their teaching strategy they developed for introducing engineering to 3-7-year-olds and contributing their engineering identity, they introduced children an engineering-centered storybook (Engineering Elephants), they designed engineering activities including academic discussions and creative drawing activity. Results revealed that engineering-centered literature enabled children to gain concrete knowledge of what engineers do and to develop an engineering identity.

Another subject examined in the studies focused on engineering education in early childhood was the integration of engineering with technology by means of robotics (Bers, 2007; Sullivan et al., 2013; Sullivan & Bers, 2018). In one of these studies, Sullivan and Bers (2018) focused on engaging preschool children with main concepts related to engineering and technology by means of robotics and programming. Participants were 98 children from five different early childhood centers who participated in a 7-week KIBO robotics curriculum in Singapore. This study indicated that children can utilize technologies like robotics starting from preschool and learn basic engineering and programming skills that form the basis for working on more complex projects in the future.

In another study conducted on engineering and robotics, Bers (2007) included parents in engineering and technology education in early childhood. In this context, Bers (2007) threw together children aged 4-7 and their parents in 5-week workshops to work on their own robotics projects. With these workshops, it was aimed to teach children and their parents about the mechanical and programming sides of the robotics, improve their knowledge and skills in robotics, and develop positive attitudes towards learning via and about technology. To that end, within the scope of this community of practice "*Project InterActions*", parents and children built and programmed an individually meaningful robotic project. Findings indicated that the knowledge of children in the pilot study conducted with only children is more than that of the children in the pilot study conducted with parents. On the other hand, more complex projects were produced in the parent-child workshop than the projects in the child-only workshop. Many of the parents stated that working with their children in a project was the most enjoyable part of the workshop and that they were pleased to see their children working without giving up on the project. Findings of the study brought light the need for parents to support teachers who desire to integrate engineering and technology into the curriculum but did not feel confident enough in their abilities.

The importance of the participation of young children in science and engineering education was also supported by other studies. For instance, in their study, Gunning et al. (2016) investigated the ways of supporting kindergarten children's learning in the disciplines of science and engineering and improving their interest in these disciplines through PI. To this end, researchers developed a model (*Family Learning Opportunities in Engineering and Science*) with two events (two family sessions and dinner) that bring together 15 parents with different demographic characteristics and their kindergarten children. In one of the family sessions, parents and children observed the responses of worms to different stimuli and noted their observations. In another session, children were able to explore musical instruments and explore the sound and sound wave concept. Later, they designed their own phones in the light of the information they had learned during this discovery. Dinners were designed to increase the self-efficacy of parents with different demographic characteristics for PI. The findings indicated that the model supported children to learn more about science and to develop their skills in scientific practices. Moreover, the model enhanced parents' self-efficacy in promoting their children's STEM-related learning.

Finally, in another study which focus on PI of preschoolers' engineering education, Bagiati et al. (2011) investigated the ways in which parents exposed their children to engineering. For this purpose, researchers focused on artifacts that exist in the home environment, how parents use them to promote their children to engineering, and parents' reports on the interaction of their children with these artifacts. According to the findings, majority of the midwives think that pre-school engineering education is important in terms of their contribution to cognitive development, general knowledge and skills, and problem-solving skills of children. The findings also revealed that many parents did not make any statements to their children or made one-word explanations when using artifacts in their home environment.

To summarize, current research points out that engineering is inherently present in young children's plays and daily activities, and children display thinking and behaviors which are precursors to engineering during these activities. However, these behaviors and thoughts are more likely to occur during structured activities and when engaged in hands-on experiences. Similarly, preschool students are very capable of developing their own solutions to the problems they face and testing and developing these solutions according to the requirements of the problem. However, all these skills have the chance to appear and develop when opportunities and support are given, and when given the opportunity, young children can overcome complex problems and produce possible solutions (Purzer & Douglas, 2018). As in some of the abovementioned research, the advantage of activities naturally occurring in preschool classrooms can be used to raise children's developing capability of engineering and design and can offer them new activities that pose preschoolers to further improve their emerging skills (Meeteren & Zan, 2010). As the research suggests, such an education process can be supported by PI (Bagiati & Evangelou, 2015; Bers, 2007). However, unfortunately, the contribution of engineering education to young children is not sufficiently recognized (Moore, Tank, & English, 2018), and therefore, in early childhood, both for engineering education and for the involvement of parents in children's education process more research and resources are needed.

In addition to all this current research, some steps have been taken to integrate engineering education into early childhood classrooms. These steps can be examined under three headings: engineering related frameworks, standards, and curricula. All these initiatives for engineering education in early childhood are described in the following sections.

2.4.3 The Curricula Developed for Early Engineering Education

In addition to the abovementioned studies, some curriculums for engineering education in early childhood (involving children aged 0-8) were also developed. These curricula are described below.

- *Engineering is Elementary Curriculum (EiE)*

The EiE curriculum, which reached millions of primary school children in America and in many parts of the world, was developed in 2003 by the Boston Team of the Museum of Science to take advantage of the innate curiosity existing in all children and to develop understanding and problem-solving skills in engineering and technology (Cunningham et al., 2018). At the end of their studies conducted with the contribution of teachers and engineers, the EiE team has developed a research-based, classroom-tested, based on elements of project-based learning, and standards-driven engineering education curriculum for elementary classrooms. In addition, by means of the EiE project, teachers have been provided with professional development in terms of improving their knowledge of engineering concepts and developing educational methods for teaching of engineering tools (Cunningham, 2009). *EiE* includes 20 units designed to attribute and implement science content by means of engineering design and related technology.

The EiE team also introduces some critical knowledge and skills which are essential to children's technological literacy and engineering education (see Table 2). According to the team, children should know what engineering and technology mean, the place and importance of engineering and technology in our daily lives, the various areas of engineering, and the problems or needs they address, and that engineers can be from different races to genders. As before mentioned, EiE curriculum addresses elementary level children (Cunningham, 2009). However, within the context of this study, these knowledge and skills were adapted to preschool children and extended by adding indicators, because it was believed that they were important for preschoolers in terms of their engineering understanding and skills.

Table 2

Essential knowledge and skills in EiE (Cunningham, 2009, p. 12)

Children should have knowledge about	• what engineering and technology are and what engineers do. • various fields of engineering. • nearly everything in the human world has been touched by engineering. • engineering problems have multiple solutions. • how society influences and is influenced by engineering. • how technology affects the world (both positively and negatively).
Children should be able to	• engineers are from all races, ethnicities, and sexes and have various abilities/disabilities. • engage in the engineering design process • apply science and mathematics to engineering problems. • use creativity and careful thinking to solve problems • envision one's own abilities as an engineer • troubleshoot and learn from failure • understand the central role of materials and their properties in the engineering solutions

In addition, the EİE curriculum was developed by considering some design principles (see Table 3). As Cunningham and Lachapelle (2016) stressed, when they develop an engineering curriculum, researchers should be sure about that engineering education is inviting and thought-provoking for all children. Indeed, some children may be underrepresented in STEM related fields or some of them may be underserved. Therefore, an inclusive engineering curriculum for all children should be prepared by guiding some design principles.

Table 3

Main design principles of EiE curriculum (Cunningham & Lachapelle, 2016, p. 4)

Category	***Design Principles***
Set learning in a real-world context	Use narratives to develop and motivate students' understanding of engineering's place in the world.
	Demonstrate how engineers help people, animals, the environment, or society.
	Provide role models with a range of demographic characteristics.
Present design challenges that are authentic to engineering practice	Ensure that design challenges are truly open-ended, with more than one 'correct' answer.
	Value failure for what it teaches.
	Produce design challenges that can be evaluated with both qualitative and quantitative measures.
	Cultivate collaboration and teamwork.
	Engage students in active, hands-on, inquiry-based engineering.
Scaffold student work	Model and make explicit the practices of engineering.
	Assume no previous familiarity with materials, tasks, or terminology.
Demonstrate that "everyone can engineer"	Produce activities and lessons that are flexible to the needs and abilities of different kinds of learners.
	Cultivate learning environments in which all students' ideas and contributions have value.
	Foster children's agency as engineers.
	Develop challenges that require low-cost, readily available materials.

- *Engineering for Kindergarten*

In recent years, the EiE team has focused their studies on the development of a research-based engineering curriculum for kindergarten children − "*Engineering for Kindergarten (EiE-K)*" − in order to introduce to them EDP and build children's confidence and curiosity in STEM. The curriculum consists of learning activities, such as the design of garbage collectors, which involve designing simple technologies but with complex structures (Major, 2018).

- *Wee Engineer*

The development process of early childhood engineering curricula showed the team that the proposed engineering activities for kindergarten and Pre-K children should be different from each other. Therefore, the team developed an engineering curriculum including activities for preschool children – "*Wee Engineer*" −. In this curriculum, the team simplified the five-step EDP utilized by kindergarten children and created a three-step process for preschoolers (explore, create, and improve) (Major, 2018). In the curriculum design process, to provide preschool children with age-appropriate challenges the team considered some points such as providing children with a simple and relevant context, selecting problems which enable multiple solutions, and demanding the tasks which is appropriate this age group's fine motor skills. The curriculum includes four learning activities and in an exemplary introductory activity, children are offered an engineering challenge through a puppet, and they are asked to find ways to make a soft pillow using a variety of materials. Then, children are introduced with the three-steps EDP by means of an engineering song written by the curriculum developers. After helping children to identify themselves as engineers through the song, children are experiencing the steps of the EDP when designing a noisemaker as a birthday present to a friend of the puppet (Davis et al., 2017).

- *Puppeteering to Engineering*

Bagiati (2011) developed a developmentally appropriate curriculum by considering the gap in the literature related to an engineering curriculum addressing preschool children. The curriculum prepared in the light of “The Creative Curriculum” (Dodge, Colker, & Heroman, 1996) and “Project Approach” (Katz & Chard, 2000) including 24 lesson plans and focus mostly on development of preschool children’s STEM related knowledge, skills, feelings and dispositions. Throughout these 24 lesson plans Bagiati (2011) touched on some engineering related concepts such as engineer, usage, decision making, construction criteria, building, building elements, design, model, maquette, sketch, and design representations.

- *Seeds of STEM*

Seeds of STEM developed by a team including researchers, teachers, and experts in different fields is a research-based engineering curriculum addressing preschool children. The curriculum aims to achieve two main learning outcomes: 1) to improve the ability of preschoolers to use STEM vocabulary properly, which is an integral part of the EDP, and 2) to improve the ability of children to carry out every step of the EDP. To achieve these learning outcomes, the curriculum includes eight different units each of which addresses different science concept (core idea) and is built around EDP. Each week, a different challenge in connection with the related science concept is introduced to children through a panda puppet, and children are expected to solve these problems by experiencing the steps of EDP. During the curriculum development process, some principles guided the team: developmentally appropriateness, culturally responsiveness, application of the EDP, integrity of the academic content, quality of technology integration, connections to Non-STEM disciplines, real-world connections and STEM careers, and nature of assessment (Dubosarsky et al., 2018, p. 258).

2.4.4 Frameworks Developed for Early Engineering Education

All these curricula mentioned in the previous subsection are developed in the light of some frameworks addressing early childhood engineering education. These frameworks that also shed light on the current study are explained below.

- *Mosaic Framework*

Purzer and Douglas (2018) proposed the Mosaic Framework in order to be a guide for assessing and supporting young children's thinking and learning in engineering. The metaphor of creating a meaningful expression by combining small pieces has inspired the formation of the framework. In this framework, main learning goals objectives constitute the base of the mosaic, classroom assessment represents the tiles, and teacher's professional development centered on assessment represents the mortar. The framework is also based on three basic principles with these three components:

1. considering the rich nature of the engineering curriculum including engineering practices and many learning objectives in main content areas such as mathematics, science, and literacy, and the complexity of the learning environment, the assessment tasks, and the scoring guidelines should be clearly identified.
2. it is important to set a clear goal for evaluation when developing or using any assessment tool.
3. since engineering education is a new area for them, teachers may not be ready to determine the important aspects of design, the level of a developmentally appropriate achievement, and how assessment can be used to facilitate student learning. Therefore, any attempt to develop any curriculum and assessment should bring teachers' professional development in the matter of knowledge, skills, instruments, and strategies for effective assessment that promotes student learning with it.

- *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*

The overall objective of the framework is that all students should appreciate the beauty and wonders of science until the end of high school; have sufficient knowledge regarding science and engineering to participate in public debates on relevant issues; to be careful consumers of technological and scientific knowledge they encounter in their daily lives; keep on learning about science in environments outside the school; and the ability to enter in their chosen careers, including science, technology, and engineering related ones. The addition of engineering and technology to the framework as well as the natural sciences is due to reflecting the importance of understanding the world created by man and to better integrate the teaching and learning of these three disciplines (NRC, 2012).

Table 4

Dimensions of the framework for K-12 science education (NRC, 2012, p. 3)

1. Scientific and Engineering Practices
Asking questions (for science) and defining problems (for engineering)
Developing and using models
Planning and carrying out investigations
Analyzing and interpreting data
Using mathematics and computational thinking
Constructing explanations (for science) and designing solutions (for engineering)
Engaging in argument from evidence
Obtaining, evaluating, and communicating information
2. Crosscutting Concepts
Patterns
Cause and effect: Mechanism and explanation
Scale, proportion, and quantity
Systems and system models
Energy and matter: Flows, cycles, and conservation
Structure and function
Stability and change
3. Disciplinary Core Ideas
Physical Sciences
Matter and its interactions
Motion and stability: Forces and interactions
Energy
Waves and their applications in technologies for information transfer
Life Sciences
From molecules to organisms: Structures and processes
Ecosystems: Interactions, energy, and dynamics
Heredity: Inheritance and variation of traits
Biological evolution: Unity and diversity
Earth and Space Science
Earth's place in the universe
Earth's systems
Engineering, Technology, and Applications of Science
Engineering design
Links among engineering, technology, science, and society

According to the Framework, K-12 science education should be built on three main dimensions: scientific and engineering practices (see Table 4). The first dimension includes the main practices employed by scientists while inquiring and constructing models and theories concerning the world. In addition, the first dimension involves the key steps followed by engineers while designing and constructing systems. The second dimension consists of concepts which have implication across all areas of science and are essential to a comprehension of engineering and science. The last dimension includes core ideas about physical sciences, life, earth and space sciences, and engineering, technology and practices of science. The Framework defends that these three dimensions should be included in standards, curricula, teaching and assessment to ensure that meaningful learning takes place in the fields of science and engineering (NRC, 2012).

The Framework is not directly focused on engineering education and does not include preschool children. However, it includes concepts and practices that can guide the integration of science, technology, and engineering not only from kindergarten to 12th grade but also for content to be prepared for preschool children. Therefore, activities in the curriculum developed within the scope of the present study were prepared in the light of these engineering related disciplinary core ideas, crosscutting concepts, and engineering practices.

- *Problem-Solving Framework for Emergent Engineers*

Another framework is the problem-solving framework proposed by Stone-MacDonald et al. (2015). This framework which was also one of the basic frameworks underlying this study was developed in the light of some essential constructivist theories. First, by adopting Piaget's (1954) constructivist approach, the framework is grounded on the idea that children construct their own knowledge base by means of their interaction and experiences with the objects surrounding them. In addition, the framework defends that children's ability to achieve new tasks can be developed with the attentive guidance of adults, and thus children can perform those tasks on their own. Indeed, with this aspect, the framework depends on the idea suggested by Vygotsky (1978) that each child has a zone of proximal development (ZPD). In this ZPD adults can propose scaffolding to allow the child to practice higher-order cognitive processes that s/he would not carry out alone. Besides, in the light of the description of Fischer, Bullock, Rotenberg, and Raya (1993) on child competence, the framework provides engineering activities for young children to help them to achieve their own potential. Fischer et al. (1993) define children's abilities as attributes they exhibit in a certain context rather than as their own personal characteristics. In this way, the framework proposes meaningful contexts offering children to find out big ideas and perform some thinking skills (curious, persistent, flexible, reflective, and collaborative thinking).

Stone-MacDonald et al. (2015)'s framework differs from other frameworks with the idea that the basic competencies required in the complex problem-solving process are mostly exhibited from infancy. In fact, this framework argues that the problem-solving process of young children from infancy can be an answer not only to problems identified by them in their daily practice but also to engineering-related problems that require creative thinking, scientific ideas and mathematical reasoning (Stone-MacDonald et al., 2015). This framework was used as the main framework in this study because it was a detailed framework on how engineering education could be carried out in the preschool years and emphasized the role of adults in the engineering education process.

2.4.5 Engineering Education Standards

- *Next Generation Science Standards (NGSS)*

The NGSS were developed based on the framework introduced by NRC (2012) and includes some performance expectations for children from kindergarten to 12th grade. Performance expectations refers to the practical to evaluate expressions of what children should know and what they should be able to do in science and engineering. For kindergarten children, performance expectations aim to contribute children to produce answers to questions related to how the world works. In this context, grade-appropriate competency in scientific and engineering practices such as asking questions, creating and utilizing models, planning and performing investigations, data analysis and interpretation, designing solutions, constructing arguments braced evidence, and acquiring, assessing, and discussing on the information were expected from kindergarten children (NGSS Lead States, 2013) (see Table 5). The NGSS performance expectations determined for kindergarten children shed light on learning objectives of the curriculum developed within the context of this study.

Table 5

Kindergarten performance expectations (NGSS Lead States, 2013, pp. 4-8)

Crosscutting Concepts	***Performance Expectations***
Motion and Stability	• Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. • Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.
Energy	• Make observations to determine the effect of sunlight on Earth's surface • Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.
From Molecules to Organisms: Structures and Processes	• Use observations to describe patterns of what plants and animals (including humans) need to survive.
Earth's Systems	• Use and share observations of local weather conditions to describe patterns over time. • Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

Table 5

(continued)

Earth and Human Activity	• Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live. • Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather. • Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.
Engineering Design	• Ask questions, make observation, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool. • Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. • Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weakness of how each performs.

2.4.6 Engineering Design Process for Young Engineers

Although the number of the steps and the intensity of the tasks in these steps are different from each other in different EDP models, as Moore et al. (2014) stressed, as in scientific inquiry, engineering design represents a process in which the decision of which steps to take in the next phase are based on the knowledge obtained in the previous phase. Engineering education should lay emphasis on a highly iterative and open-ended EDP in which there are multiple possible solutions to a problem. Moreover, EDP should integrate scientific, technological, and mathematical concepts in meaningful content, and stimulate system thinking, prototyping and analyzing (Katehi et al., 2009). Research have indicated that preschool children have been able to successfully perform the steps of EDP (Bagiati & Evangelou, 2016; Davis et al, 2017). In fact, preschoolers experience engineering while inventing a new glue by bringing the various components together, while building castles and while creating roads by use of various materials like sand, wood, bottles (Smetana et al., 2012). Therefore, engineering design is a part of preschool children's daily life experiences (Lippard et al., 2017). On the other hand, as Hynes et al. (2011) emphasized, the purpose of enabling children to engage in EDP is not to make them build things. Contrary to this common misconception, EDP allows children to understand that engineering is concerned with the organization of ideas to improve decision-making in order to develop high-quality solutions or products for problems.

When it comes to EDP that can be used in preschool engineering education, it is possible to encounter a wide variety of EDP models proposed for use in early childhood classrooms (e.g. Bagiati & Evangelou, 2016; Davis et al., 2017; Hoisington & Winokur, 2015; Lottero-Perdue et al., 2016; Stone-MacDonald et al., 2015). The curriculum activities developed in the present study were based on the four-step model proposed by Stone-MacDonald et al. (2015). Stone-MacDonald et al. (2015) consider the EDP as an exemplar problem-solving framework in order to design learning experiences which promote young children's STEM learning and their cognitive development. According to this model, the EDP consists of four main phases (think about it, try it, fix it and share it) on which adults and children need to work together. This model also focuses on five ways of thinking (curious, persistent, flexible, reflective and collective thinking). According to Stone-MacDonald et al. (2015), engaging in engineering experiences can help young children in developing these thinking skills, which are essential for adult engineering. Moreover, those skills displayed by young children raise their readiness toward success in STEM learning and thinking as problem solvers. These skills are also the main constituents of real-life engineering design (see Figure 6).

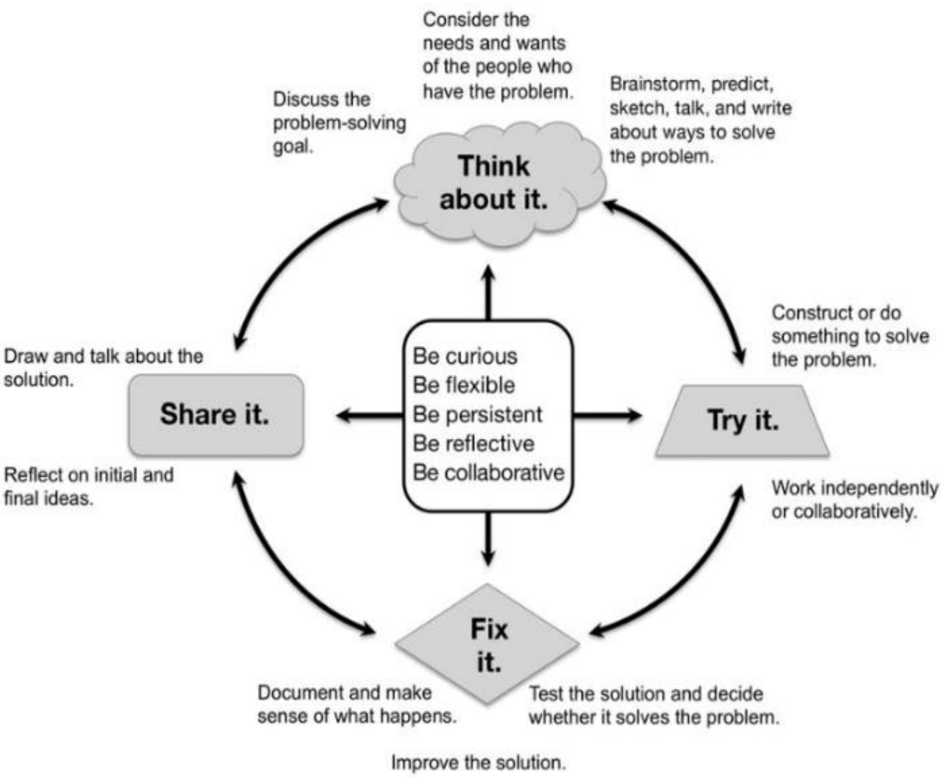

Figure 6 The phases and thinking skills constituting the EDP (Stone-MacDonald et al., 2015, p. 12).

2.4.7 Engineering-related Thinking Skills

The problem-solving framework proposed by Stone-MacDonald et al. (2015) focuses on five main thinking skills which include overlaps between engineering and the development process of young children. By considering National Science Standards for young children, these thinking skills were determined as foundational skills that children, from their infancy to preschool years, should learn at diverse levels of complexity.

2.4.7.1 Curious Thinking

Curiosity can be defined as the desire of learning, exploring, revealing and acquiring the knowledge concerning oneself and the universe (Stone-MacDonald et al., 2015). During their everyday experiences, children observe and interpret the running of the universe. Their curiosity makes them think of and interrogate theories (Loxley, Dawes, Nicholls, & Dore, 2014). As a matter of fact, every child is born as thinkers who wonder about objects, events or people, and tries to make sense of the world by searching for patterns and discovering new ones. Children's curiosity fuels their learning by providing them with internal motivation and develops their creativity. Children who are curious thinkers can acquire the ability to see multiple possibilities and can go beyond outside the box (Stone-MacDonald et al., 2015).

Research revealed that children who had higher curiosity ask more questions and that they are also more skilled in utilizing questions to solve problems and discriminating useful questions (Jirout & Klahr, 2011). In addition, studies focusing on science education consider curiosity as an essential element in inquiry-based learning (e.g. van Schijndel, Jansen, & Raijmakers, 2018). Curious thinkers find out and examine ways to find answers about how something happens by asking "Why?" questions (Trilling & Fadel, 2009), display a willingness to learn about a wide variety of subjects and ideas, utilize a large number of sources to find answers to their questions (Stone-Macdonald et al., 2015), think and pose questions about theories and phenomena (Loxley et al., 2014).

Curiosity is also an important feature of professional engineers. Engineers spend a significant amount of their time trying to solve problems and ask questions before they start to propose solutions to the design problems (Atman et al., 2007). In addition, when they conduct predictive analysis, engineers utilize their curious thinking skills to foreknow how potential solutions might correctly perform in design problems. Hence, engineering education in early years aims to touch on children's natural curiosity in order to encourage their learning of concepts regarding engineering and technology. Engineering design experiences help children explore the design and development of today's human-made world by piquing their curiosity (NRC, 2010).

2.4.7.2 Persistent Thinking

Thomas Edison worked on reaching correct materials to create an effective incandescent lamp (fuses, sockets, plus the wiring, and generators to activate them) for one and a half years. Eventually, he created an invention which has improved the life quality of most people around the world. His ambitious and never-ending persistence in solving complicated problems has constituted an example of the persistent thinking of engineers, technologists and learners (Trilling & Fadel, 2009). Indeed, persistence means staying in touch with the problem until a satisfying solution is found (Walsh, Murphy, & Dunbar, 2007). Persistent thinkers are involved in challenging work and attempt numerous tries. Likewise, engineers redesign iteratively and go through a cycle by repeating attempts at each step of the design procedure, from restoring their definition of the problem to building in a multitude of prototypes, to suggesting a variety of options for selecting materials and final specifications. In this way, engineering design experiences provided for children require being a persistent thinker throughout the problem-solving procedure (Stone-MacDonald et al., 2015).

The study conducted by Van Meeteren (2013) revealed that preschool children did not give up when they had a failure in a test, but rather went on to develop their designs. In fact, in the study, there were only a few children who succeeded in their first attempt, and other children tried again and again until they solved the problem. Engineering experiences enable children to cope with disappointment in failure situations and to continue without giving up for success (Cunningham et al., 2018). In fact, the iterative process including numerous trial and errors in the EDP provides children with an optimistic world view based on the belief that every challenge can include different possibilities and opportunities (Van Meeteren, 2018). The motivation to keep on working for the task despite the unsuccessful trials and to be persistent is valuable for children in their learning journey (Lippard et al., 2018). According to the study conducted by Robson and Rowe (2012), preschool children demonstrated more persistence in child-initiated activities, however, that adult presence supported their persistence and deal with challenges. In other words, children need to be supported to improve their behaviors which are the mediators of success, such as persistence and collaboration (Cunningham et al., 2018).

2.4.7.3 Flexible Thinking

As Daly, Adams, and Bodner stressed (2012, p.199), "design is freedom to create any of an endless number of possible outcomes that have never existed with meaning for others and/or oneself within flexible and fluid boundaries." In fact, while experimenting with a design solution model, engineers get new information about how well their solutions work and adapt their ideas by considering this new information. As in engineering, flexible thinking, which is one of the key thinking skills for complex problem-solving experiences required in the STEM disciplines, makes it possible to accommodate oneself to ever-changing knowledge and aims (Stone-MacDonald et al., 2015).

Flexible thinking which is known as also cognitive flexibility (Barak & Levenberg, 2016) can be defined as "a cognitive system that underpins the ability to change perspective, shift attention between tasks or mental sets, and adjust to changing demands and problems" (Stad, Wiedl, Vogelaar, Bakker, & Resign, 2019, p.125). Preschool years are the beginnings of flexible thinking, which is required for exploring creative solutions to the problems. Research revealed that flexible thinking develops a considerable extent from the age of 3 to 6 (Deák & Wiseheart, 2015). By these ages, the aim of children is to start to implement flexible thinking in the creation of new tools (Stone-MacDonald et al., 2015). In fact, as Kiewra and Veselack (2016) emphasize, flexible thinking is a critical skill for preschool children to be individuals in the future who are productive and contributing to society. In addition, research revealed that cognitive flexibility predicted children's potential for learning (Ropovik, 2014; Stad et al., 2019), their early reading (Colé, Duncan, & Blaye, 2014) and mathematical skills (Kercood, Lineweaver, Frank, & Froom, 2017).

Flexible thinkers are flexible in taking into consideration alternative ideas (Griffin, McGaw, & Care, 2012), observe and imitate the ways of problem solving of other people, look for solutions to the problems and use it, think on the problem by considering various possibilities and examining the results, represent her/his solutions to the problem by means of models (prototypes), transfer her/his ideas to new circumstances (Stone-MacDonald et al., 2015). They also embrace various roles, responsibilities, program and contents, work efficiently in uncertainty, accept feedback, cope with praise, criticism and failure, and comprehend, negotiate and balance varied opinions to achieve a workable solution (Partnership for 21st Century Skills [P21], 2009).

2.4.7.4 Reflective Thinking

Reflection serves as a means for relieving and recalling experience to attribute meaning to it, to profit from it, and to acquire new apprehensions and appreciations (Knapp, 1992). Indeed, reflective thinking is to keep oneself aloof from instantly responding to an object or incident, and rather is to represent it in your mind, recall it afterward, analyze it, and later plan and practice next step (Stone-MacDonald et al., 2015). Research conducted on children's reflective thinking indicated that it is associated with children's executive function, which is a set of cognitive processes that deliberately leads the regulation of behavior. Indeed, reflection allows children's conscious thoughts to have more impact over their actions. (Stone-MacDonald et al., 2015).

When children are engaged in reflection, they are encouraged to go beyond only reporting the work they've done. In fact, by means of reflection, children are helped to be conscious of their learning occurred in the process, the interesting points, their feelings about that learning experience, and what can be done for developing the experience. Reflection strengthens the knowledge, thereby, it can be possible to generalize knowledge to other situations and to lead to further estimation and evaluation (Epstein, 2003). In line with this, studies revealed that learning processes fostering children's reflective thinking supported also their science-related learning and attitudes (Tok, 2008).

Reflective thinking is also the backbone of the work carried out by scientists and engineers. In fact, each step of scientific exploration and an EDP requires making decisions concerning what to do in the following phase. To take those decisions, engineers and scientists must acknowledge what practices they have performed and what data they have collected up to that point. They evaluate those practices and data to identify whether they are one step closer to responding to a question or purposing a solution (Stone-MacDonald et al., 2015).

2.4.7.5 Collaborative Thinking

Gaining a critical perspective on what someone else is talking about, understanding and solving problems, creating new knowledge and innovations to create a better world, communicating and collaborating with others in learning is considered one of the core skills for learning and innovation in the 21st century (Trilling & Fadel, 2009). Collaboration is also one of the engineering habits of mind. In fact, engineering can be considered as a "teamwork", and engineering design is a considerably social and collaborative attempt. Collaboration fosters viewpoints, knowledge and abilities of team members to handle a design challenge. Engineers also work collaboratively with scientists in teams and employ scientific tools and strategies to carry out better observations because engineering practices require teaming up with people who have different knowledge and abilities (NRC, 2010).

Collaborative thinking is important not only for professional engineers, but also for young engineers and their problem-solving processes. Collaborative thinking necessitates cognitive and social skills, and it allows a child to effectively engage in collaborative behavior. Indeed, real-life problems are resolved by effective and collaborative work of group or teams rather than a single person (Stone-MacDonald et al., 2015). Similarly, while young children are engaged in engineering activities, they exchange ideas with one another to make their designs work, offer advice and support to others, and they even work to discover how to integrate two smaller work systems into a larger system (Van-Meeteren & Zan, 2010).

Collaboration can also play a key role in development since it challenges the child's individual schema. In fact, successful cooperation has the power to make children aware of multiple perspectives and contribute them to more deeply think about materials, concepts, and ideas (Lippard et al., 2018). Research also has revealed that peer collaboration can help preschool children build friendship, help each other and inspire each other (e.g. Svinth, 2013).

2.4.8 STEM and Engineering in Turkish ECE Context

Many countries, especially the United States and European Union countries, have started efforts to extend STEM education from preschool to university level (Çakıroğlu, 2018). In this context, as described in detail in the previous chapters, some national standards (NGSS Lead States, 2013; NRC, 1996), including various learning outcomes for STEM education, guidelines (NRC, 2015) and assessment strategies (NRC, 2014) for the implementation of these standards, strategic plans (National Science and Technology Council, [NSTC], 2018) and the frameworks for STEM have been developed (NRC, 2011; 2012). As in STEM, the efforts to develop standards (Katehi et al., 2009) and frameworks (Moore et al., 2014) for K-12 engineering education have been continued for many years.

Similarly, there have been several developments in STEM education in Turkey. STEM has attracted the attention of both educators and the Ministry of National Education (MoNE) especially since 2015. In this context, various STEM education reports (Akgündüz et al., 2015; Turkish Industry and Business Association [TÜSİAD], 2014, 2017; MoNE, 2016) have been published various projects have been initiated for the integration of STEM education into schools (e.g. Development of STEM Education and Industry 4.0 Awareness in Vocational High Schools). In addition to supporting these projects, with the renewal of curricula in 2018, science, engineering and entrepreneurship practices, engineering and design skills, science, engineering and technology relations are included in the science curricula (MoNE, 2018). On the other hand, the majority of these developments focus on primary and high school education levels and STEM and engineering in preschool education are not adequately represented (Akgündüz & Akpınar, 2018). In fact, it is seen that STEM education related academic sources are limited to only a few book chapters (Akgündüz & Akpınar, 2018; Çil, 2017) and a handful of studies (Ata-Aktürk & Demircan, 2017; Ata-Aktürk et al., 2017; Çetin, Ata-Aktürk, & Demircan, 2018; Çetin & Demircan, 2018; Koyunlu-Ünlü & Dere, 2018; Soylu, 2016; Uğraş, 2017; Uyanık-Balat & Günşen, 2017). Findings from these limited number of studies showed that preschool children have a high motivation and positive attitude towards STEM activities

(Akgündüz & Akpınar, 2018), and also acquired 21st century skills and various concepts of science and mathematics during these activities (Akgündüz & Akpınar, 2018; Günşen, Fazlıoğlu, & Bayır, 2018). Similarly, studies conducted with preschool teachers indicate that teachers have a positive attitude towards improving themselves in STEM education (Uğraş, 2017). In addition to these studies, it was found that Turkish ECE curriculum allows STEM integration because of its some aspects overlapping STEM education. In fact, Turkish ECE curriculum included the disciplinary core ideas (e.g. physical science) and crosscutting concepts (e.g. pattern, cause, and effect) that enable the integration of STEM education into K-12 science education. On the other hand, the curriculum was found to be quite limited in the context of engineering and technology related content (Ata-Aktürk et al., 2017).

When this research is reduced to the studies related to engineering in preschool education, a few studies are encountered in the literature (Ata-Aktürk & Demircan, 2018a, 2018b). In one of these studies, Ata-Aktürk and Demircan (2018a) aimed to focus on Turkish preschool children's understanding of engineer and engineering. A total of 439 children from 16 different cities were examined and a large majority of the children had drawings that were not related to engineering, and others were depicted engineer as a construction foreman or repairman. In another study, the same researchers examined the children's picture books written in Turkish or translated into Turkish in terms of steps of the EDP. The findings indicate that picture children's books can be used as a tool for engineering education in preschool, and that the number of children's books in which the EDP is handled at all steps was quite limited (Ata-Aktürk & Demircan, 2018b).

Considering this limited literature on STEM and engineering in the preschool period, we encounter the fact that there are more steps to be taken as researchers, educators, curriculum developers, teachers and parents. As Uyanık-Balat and Günşen (2017) emphasized, providing opportunities for children to participate in educational activities and practices appropriate to STEM approach in early childhood is seen as one of the most important investment areas that can be made to children of this age in Turkey. Besides, parents should also be involved in this education process in order to guide their children to improve knowledge and skills learned in school (Akgündüz & Akpınar, 2018; Uyanık-Balat & Günşen, 2017). This perspective brings the researcher to the point that understanding, developing an engineering-oriented curriculum which includes parents as a stakeholder of the process and is appropriate for the development and learning characteristics of preschool children might provide many learning outcomes in STEM (Bagiati & Evangelou, 2015). In this regard, one of the main dimensions of this study was considered as PI, and EDCPI was structured around the following PI literature.

2.5 Parental Involvement

The curriculum designed and developed in this study grounds on the partnership between parent, teacher and child. Therefore, all the content of the study was shaped in the light of the literature on PI. At that point, in addition to the current studies in the literature, Epstein's and Hoover-Dempsey and Sandler's PI models, scaffolding strategies and the "Family Support Education Guide Integrated with ECE Program [OBADER]" developed by MoNE (2013) were utilized as main resources by the researcher. The following sections summarize the theoretical background of PI underlying the current study.

2.5.1 Definition of Parental Involvement

PI which refers to the connection between school and family is a constituent of an effective education merits to be particularly considered because of its contribution to creating a successful home environment and to children's success (Epstein, 2011). In fact, the importance of strong relationships between the child's family and the school environment for both child development and education has been acknowledged by many researchers (Epstein, 2011; Hornby, 2011; Lau, Li, & Rao, 2012; Jeynes, 2005; Marjanovič-Umek, Fekonja-Peklaj & Podlesek, 2014; Neumann & Neumann, 2010; Robinson & Harris, 2014; Wheeler & Connor, 2009). Research conducted in this field has convincingly revealed that PI is critical for the child's learning process and attitudes toward school, and children who have parents participating at the school and fostering their learning at home environment are more successful regardless of the educational status or social class of their parents (Epstein, 2011). On the other hand, in this PI literature, researchers' definitions of PI have varied from one another (Erkan, 2013). Some of these definitions adopt more traditional approaches which focus on the ways of parents can contribute to the school (e.g. support the child in her/his homework, parent-teacher meetings, fundraising, and volunteering). In the traditional approach to the definition of PI, power is mostly owned by schools, and the content, purpose and agenda of participation is determined by schools. On the other hand, contemporary approaches to PI is more comprehensive in terms of cultural and social aspects (Latunde, 2017) and recognizes that education of children is a responsibility shared by parents, school and the community (Epstein, 2011). In other words, the contemporary approach equally distributes power to the parents, school and the community. It deals with family involvement in a broader context by considering the cultural and social diversity and the PI outside the school environment (Latunde, 2017).

In addition to these different approaches to PI, researchers have defined and measured PI inconsistently in their studies based on the aims of their research (Lau et al., 2012). For instance, some researchers mostly focused on academic dimension of PI. One of these researchers, Jeynes (2005, p. 245), defines PI as the active participation of parents in their children's education process and educational experiences. Similarly, according to Hill and Taylor (2004), PI may be defined as the interactions established between parents and school, or between parents and their children to support academic success. According to Punter, Glas and Meelissen (2016), PI can be considered as an umbrella term which contains parents' numerous behaviors and practices directly or indirectly relevant to their children's education. On the other hand, some researchers focus on the education-related dimension of PI as well as development related dimension. For instance, Hindman, Miller, Froyen and Skibbe (2012) emphasize that families can contribute their children's learning and development process by actively involving in versatile social contexts such as home and school environment, or community. This active involvement is related to such that parents are interested, knowledgeable and willing to play an active role in their children's daily activities (Wong, 2008). Even if these definitions of PI are different from each other, all of them emphasize the strengthening of the relationship between the two institutions, such as the family and school, where the child lives, and that the family should take a more active role in the education of the child (Erkan, 2013).

Despite abovementioned different definitions, PI can generally be defined as the active involvement of parents in the development of their children in social, emotional and academic areas (Castro et al., 2015) as well as in their educational experiences (Jeynes, 2005). Parents can be involved in their children's education in different ways. Indeed, parent involvement can be carried out at home, at school and in the community (Hindman et al., 2012). In home-based parent involvement, parents carry out academic reinforcement activities such as reading books with their child or listening the child's reading (Hornby & Lafaele, 2011), scaffolding the child's writing skills (Neumann, Hood, & Neumann, 2009; Neumann & Neumann, 2010), getting involved in educational games or supervising the child's homework (Calzada et al., 2015; Mora & Escardíbul, 2018). On the other hand, school-based involvement includes parents' voluntary participation in classrooms by means of some activities, such as teaching participating parent-teacher meetings and parent education workshops organized by the schools (Hornby & Lafaele, 2011). In addition, parents can be involved in decision making processes in school, and they can be involved in their children's education process by sharing information about their children with teachers and other school staff. Finally, community-based participation refers to the participation of parents in the community of children through activities such as visiting museums, zoos, and library with children or attending sports activities. (Hindman et al., 2012).

2.5.2 Parental Involvement and Parental Engagement

Parental engagement is a debated subject for some researchers and policy makers. Indeed, it is frequently confused with PI or parent participation (Emerson, Fear, Fox, & Sanders, 2012). Involvement have the meaning of "the act of taking part in an activity or event, or the way in which you take part in it" (p. 930), while engagement is defined as "being involved in an activity" (Longman Dictionary, 2014). According to Goodall and Montgomery (2014), parental engagement in schools refers a greater commitment and ownership of the act when compared to just involvement of parents in an activity. Similarly, Emerson et al. (2012) emphasize the distinction between involvement of parents in schooling and engagement of parents in their children's learning. According to them, PI in activities carried out in school may be an attempt which has a social function, however, parental engagement with their children's learning outcomes is the key factor create a positive change in children's success. Indeed, parental engagement which bases on the partnership between parents, schools and communities, increases parental awareness of the benefits of participating in the child's education process and provides parents with the skills necessary to do so (Emerson et al., 2012).

In its nature, the EDCPI bases on parental engagement. Indeed, in this curriculum, learning bases on the partnership between the teacher, parents, and children. All the activities within the curriculum propose some design problems, and children and their parents produce solutions to these problems by working collaboratively. That is, all the activities address some learning outcomes to be reached by children, and parents actively guide their children's learning process and learn how to support their children's engineering education. Throughout these activities, parents engage in and experience all the steps of EDP with their children and learn how to teach some engineering and STEM-related concepts to a child. Such a partnership may support parents to provide their children with learning opportunities in engineering and to promote them to correctly guide their children's engineering experiences at home. On the other hand, due to the abovementioned limited and conflicting literature on parental engagement, the term of PI is selected to use throughout EDCPI. Besides, the theoretical background of EDCPI is based on the PI theories, models, and research explained in the following subsections.

2.5.3 Parental Involvement Models

In the literature, various PI models have been developed to better understand parent involvement and take the advantage of it in research and practice. The models developed by Epstein (1995) and by Hoover-Dempsey and Sandler (1995) are two widely accepted and used

PI models in the education field. Hence, the PI dimension of the EDCPI was developed in the light of these two models.

2.5.3.1 Parental Involvement Model Proposed by Epstein

Epstein who defines PI as a major contributing element to child development (Epstein, 2001) introduced the most widely used PI model at 1990s. This model has guided schools to develop educational programs and policies that encourage parent participation in schools (Latunde, 2017). Epstein defends that educators should see every student as a child. According to her, seeing the grand picture that parents and their community are partners of the child's education and development process is only possible in this way. In this partnership, parents, schools, and the community should be aware of their common responsibilities for and interests in the child and work collaboratively to produce better opportunities and educational programs for the child (Epstein et al., 2009). From this point of view, Epstein (1995)'s model handles PI under six different dimensions:

- *Parenting* refers that the school contributes all families to building a positive home environment to promote the child as a student. Trainings organized for parents; suggestions provided by school about home conditions to promote children's learning; parent support programs organized to facilitate parents about some topics such as health and nutrition; home visits; and workshops aiming to make meaningful relevance to a topic that is present in various forms that can be seen, heard and read at any time and place are some examples of the parenting dimension (Epstein, 2010).
- *Communicating* refers to designing an effective communication between school and home concerning how the child progress, and school programs. Parent-teacher conferences conducted at least yearly with each parent and sending the child's folders including his/her weekly or monthly works to the home to be reviewed and commented are some examples of the communicating dimension (Epstein et al., 2009).
- *Volunteering* means the assistance provided by the parents to contribute the schools' functioning. For instance, some parents may participate in volunteer programs to assist teachers, school administrations, children, and other parents, or implementing annual surveys to determine volunteers' competences, available times and locations can be considered as volunteering practices (Epstein et al., 2002). Moreover, teaching small groups or participating in children's trips can be considered other ways of volunteering (Hindman et al., 2012).

- *Learning at home* aims to support parents and provide them ideas about the ways of helping their children at home in their homework, and other curricular activities, planning, and decisions. Informing parents about homework policies and the ways of monitoring and negotiating schoolwork at home (Epstein, 2009), carrying out academic reinforcement activities such as reading books with their children, getting involved in educational games or guiding their children in homework are some examples of learning at home dimension of parent involvement (Calzada et al., 2015). In this dimension, helping at home refers to fostering, listening, guiding, monitoring, and negotiating the school subjects rather than teaching them (Epstein et al., 2009).
- *Decision making* refers to inclusion of parents in school related management decisions such as creating independent advocacy communities in order to meet and work for school-related reforms and improvements and forming a network to come into contact all parents with parent representatives (Epstein, 2010).
- *Collaborating with community* represents detecting and using community resources and services to strengthen school programs, child education and development, and parental practices. Obtaining information about community activities with regard to learning skills and competences such as summer schools for students is a way of collaborating with the community (Epstein, 2010). Similarly, the participation of parents in the community of children through activities such as visiting museums, zoos, and library with children or attending sports activities are other examples of such an involvement (Hindman et al., 2012) (see Table 6).

Epstein's model shed light on this study in the matter of planning how parents would be involved in their children's engineering education process. In this regard, in the current study, even if all these PI types were provided because of the nature of the study, by means of the developed curriculum parents were specifically aimed to involve in the education process through three types of involvement among explained above. First, this study was a volunteering activity in which parents assist their children's education process by scaffolding and contribute to the school's functioning. This volunteering activity aimed to improve parents' self-efficacy in working with their children and the school and to give parents the message that they are valuable in the education of their children. Secondly, this study aimed to involve parents in education through parenting. The implementation process of the curriculum designed and developed in this study was an education process not only for children but also their parents. In parental training, it was aimed to improve parents' understanding of how to support their children's engineering education. Then, throughout the

Table 6

Parental involvement types and relevant results for each dimension proposed by Epstein (2010, p. 87)

Dimensions	***Results for parents***	***Results for children***	***Results for teachers***
Parenting	• Understanding of and confidence about parenting, child and adolescent development, and changes in home conditions for learning as children proceed through school. • Awareness of own and others' challenges in parents. • Feeling of support from school and other parents.	• Awareness of family supervision; respect for parents. • Positive personal qualities, habits, beliefs, and values as taught by family. • Balance between time spent on chores, on other activities, and on homework. • Good or improved attendance. • Awareness of importance of school.	• Understanding families' background, cultures, concerns, goals, needs, and views of their children. • Respect for families' strengths and efforts. • Understanding of student diversity. • Awareness of own skills to share information on child development.
Communicating	• Understanding school programs and policies. • Monitoring and awareness of child's progress. • Responding effectively to students' problems. • Interactions with teachers and ease of communication with school and teachers.	• Awareness of own progress and of actions needed to maintain or improve grades. • Understanding of school policies on behavior, attendance, and other areas of student conduct. • Informed decisions about courses and programs. • Awareness of own role in partnerships, serving as courier and communicator.	• Increased diversity and use of communications with families and awareness of own ability to communicate clearly • Appreciation for and use of parent network for communications. • Increased ability to elicit and understand family views on children's programs and progress.
Volunteering	• Understanding teacher's job, increased comfort in school, and carry-over of school activities at home. • Self-confidence about ability to work in school and with children or to take steps to improve own education. • Awareness that families are welcome and valued at school. • Gains in specific skills of volunteer work.	• Skill in communicating with adults. • Increased learning of skills that receive tutoring or targeted attention from volunteers. • Awareness of many skills, talents, occupations, and contributions of parent and other volunteers.	• Readiness to involve families in new ways, including those who do not volunteer at school. • Awareness of parents' talents and interests in school and children. • Greater individual attention to students, with help from volunteers.

Table 6

(continued)

Learning at Home	• Know how to support, encourage, and help student at home each year. • Discussions of school, classwork, and homework. • Understanding of instructional program each year and of what child is learning in each subject. • Appreciation of teaching skills. • Awareness of child as a learner.	• Gains in skills, abilities, and test scores linked to homework and classwork. • Homework completion. • Positive attitude toward schoolwork. • View of parents as more similar to teacher and of home as more similar to school. • Self-concept of ability as learner.	• Better design of homework assignments. • Respect for family time. • Recognition of equal helpfulness of single-parent, dual-income, and less formally educated families in motivating and reinforcing student learning. • Satisfaction with family involvement and support.
Decision Making	• Input into policies that affect child's education. • Feeling of ownership of school. • Awareness of parents' voices in school decisions. • Shared experiences and connections with other families. • Awareness of school, district, and state policies	• Awareness of representation of families in school decisions. • Understanding that student rights are protected. • Specific benefits linked to policies enacted by parent organizations and experienced by students.	• Awareness of parent perspectives as a factor in policy development and decisions. • View of equal status of family representatives on committees and in leadership roles.
Collaborating with Community	• Knowledge and use of local resources by family and child to increase skills and talents or to obtain needed services • Interactions with other families in community activities. • Awareness of school's role in the community and of community's contributions to the school.	• Increased skills and talents through enriched curricular and extracurricular experiences. • Awareness of careers and of options for future education and work. • Specific benefits linked to programs, services, resources, and opportunities that connect students with community.	• Awareness of community resources to enrich curriculum and instruction. • Openness to and skill in using mentors, business partners, community volunteers, and others to assist students and augment teaching practices. • Knowledgeable, helpful referrals of children and families to needed services.

implementation process, parents experienced sample engineering activities and saw the sample questions to be asked for supporting early engineering and STEM. Thirdly, the curriculum proposed in the current study aimed to provide parents some home-based involvement activities to be applied outside the school. With these activities, it was aimed to make parents continue to help their children to reinforce their learning. In addition, these activities provided examples where parents, who have difficulty in supporting their child's education due to lack of time, can support their children's learning in engineering and science during their daily life activities. In fact, the opportunities offered by parents to their children in terms of engineering experiences influence children’s knowledge and skills in engineering and their attitudes towards the engineering profession as a career field (Dorie et al., 2014; Smetana et al., 2012). Therefore, parents who involve in their children’s engineering education process and undergo hands-on engineering experiences with their children may offer more engineering-related opportunities outside the school environment to their children. For this reason, children’s attitudes towards and knowledge and skills in engineering may indirectly improve as a result of PI. Furthermore, as Stone-MacDonald et al. (2015) emphasize, adults may serve as a role model for their children in engineering-related thinking skills throughout the engineering design experiences. Hence, parents who experience EDP in cooperation with their children may influence their children’s thinking ways and improve the thinking skills demonstrated by children. For this reason, it was thought that this study would directly and indirectly contribute preschool children's knowledge and skills in engineering, their thinking ways and attitudes towards the engineering profession.

2.5.3.2 Parental Involvement Model Proposed by Hoover-Dempsey and Sandler

Another widely used parent involvement model was developed by Hoover-Dempsey and Sandler (1995). Although Epstein's PI model is comprehensive and useful, it takes the PI process into consideration from the perspective of the parents rather than the parents. On the other hand, evaluation of the subject-matter from the side of parents provides the researchers with an in-depth understanding. Indeed, majority of the activities within the PI dimensions are begun by the school staff, generally by the teachers. However, if parent involvement is to be investigated and strengthened, perspective of the parents, as the main actor of the PI, should be handled as a main dimension in a PI model. Indeed, the factors which form parents’ decisions about involvement needs to be considered (Anderson & Minke, 2007). From this point of view, another widely used parent involvement model was developed by Hoover-Dempsey and Sandler (1995). In their model, Hoover-Dempsey and Sandler (1995, 1997) addressed the complicated feature of factors which support or obstacle PI and interactions between these factors. The model which reveals parents' principal decision to be involved in their child's schooling and the elements related to their decision underwent a revision in 2005 (Walker, Wilkins, Dallaire, Sandler, & Hoover-Dempsey, 2005). This revised version involving five levels is presented in Figure 7.

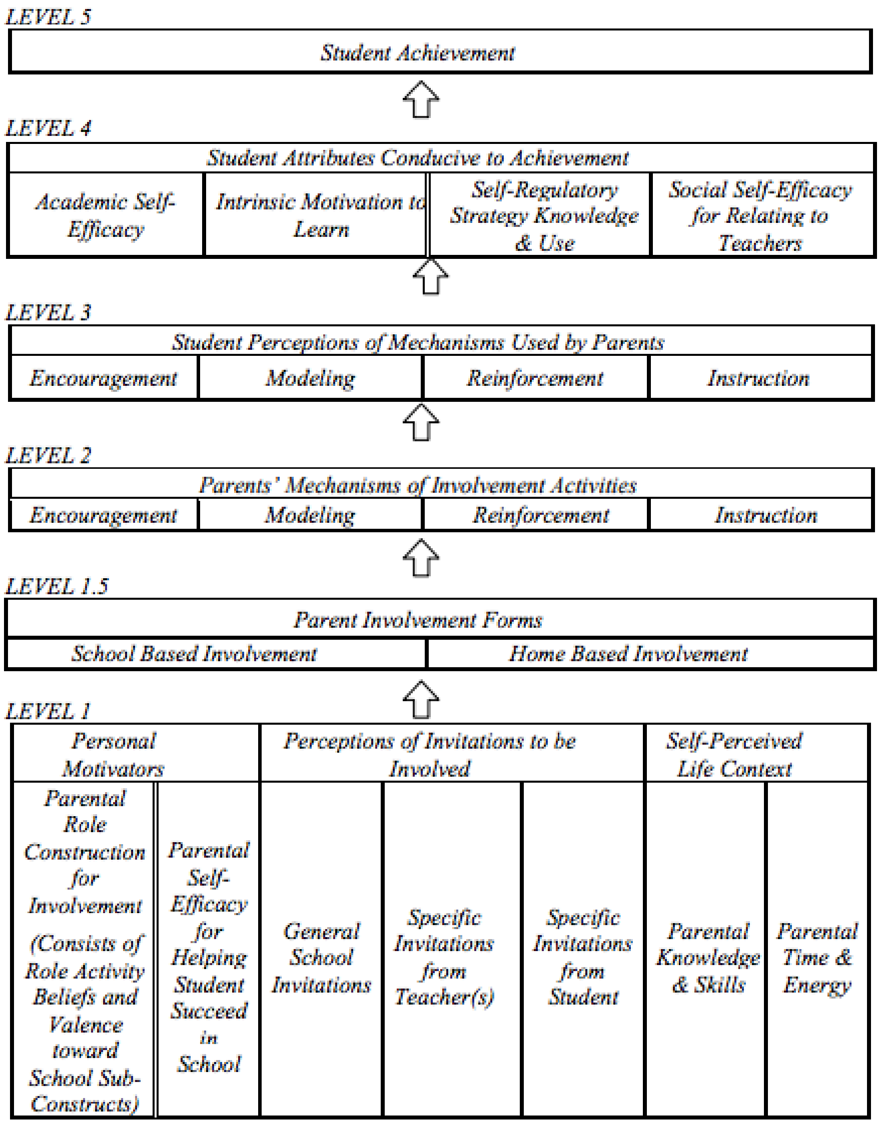

Figure 7 The theoretical model of PI proposed by Hoover-Dempsey and Sandler (1995, 1997) (Walker et al., 2005, p. 86).

In the first level, the elements affecting parents' initial determination to be involved in schooling take place. These involve parents' motivational beliefs including parental role construction for being involved (parents' feeling of responsibility for their child's schooling), and parent's sense of efficacy (belief of the parents in their potential to contribute their child's academic achievement) (Hoover-Dempsey et al., 2005). In addition, the first level involves parents’ apprehension of invitations from persons, involving the school staff, their child’s teacher, and their child. Finally, the perceptions of the parents about their living conditions such as their socio-economic status, their culture, and especially their perception of the sources of time, energy, knowledge and skills are included in the first level (Lavenda, 2011).

All these mentioned factors result in various forms of involvement constituting the second stage of the model. Indeed, forms of PI are affected by the location (school or home) where the participation is realized. On the other hand, the third level of the model contains the mechanisms of PI; in other words, strategies used by the parents to affect their child’s schooling such as being model, providing reinforcement, and instructions. The fourth level involves two components mediating the influence of PI on student success. These include the age of the child and how much the expectation of the school overlaps with the actions of the parents. Lastly, the fifth level includes the outcomes of students, including self-efficacy towards school success, and skills and knowledge (Lavenda, 2011) (see Figure 7).

The current study aims to address the first three levels of this model (Level 1, Level 1.5, and Level 2) and the factors affecting parents’ PI decisions. Indeed, for the first level, including parents into their children’s educational activities may convey them the message that their children’s education is the joint responsibility of multiple stakeholders including the parents, the teacher and other school staff and the community. The curriculum proposed by this study as a PI activity for preschool classrooms might improve parents’ awareness of the importance of early engineering education and the role of parents in their children’s engineering education process. In other words, the curriculum presented in this study may enable parents to understand that they have responsibilities in their children’s not only literacy, science or mathematics education but also in their engineering education. Thus, it can contribute to the role constructions that have an impact on their involvement in education. In addition, through such a curriculum, parents involved in the education of their children can witness their children's learning, which can increase their self-efficacy for PI. In other words, giving parents an opportunity to engage in engineering activities with their children may make them aware of their potential to contribute to the child's education. The learning process provided by this curriculum may also improve parents’ knowledge of early engineering education and their knowledge about the role of engineering in preschool children's daily activities. In addition to their knowledge, such a learning process in which parents experience EDP with their children and scaffold their children's learning may also contribute to parents' skills to support their children’s learning. Seeing that she can be involved in her child's education and her potential in this regard, the parent who has witnessed her child's development can devote more time and energy to participate in education. In other words, such a learning process provided by this study can be effective on parents' perception of their life context, which has a significant impact on their involvement in and outside the school. In addition, organizing a parent-child engineering workshop and inviting parents to this event can affect parents' perception towards invitation of school staff positively. This positive effect may cause families to cooperate with the school for the sake of their children's education. Observing that their families learn together with them and through trial and error in such a workshop can affect the academic success of preschool children positively. Finally, the scaffolding strategy proposed to be used by parents in the learning process provided by this study is parallel with encouragement, modeling, and reinforcement mechanisms of parents. In fact, this study may provide parents with the knowledge of scaffolding strategy and the opportunity to experience it during EDP. This knowledge and experience may be effective in the strategies used by parents to support their children's education process. In this way, parents may be a model for their children in terms engineering thinking, may encourage their children to produce ideas and test them, and may reinforce their children's efforts to learning by designing.

2.5.4 The Importance of Parental Involvement in ECE

PI into education process provides benefits for not only children but also parents and educators (Epstein, 1995; OBADER, 2013). In the light of relevant literature, these benefits can be summarized as follows;

- *Benefits for children:* Research signify that PI promotes children's learning and their attitudes towards school (Hornby, 2011). Indeed, children whose parents are involved in school and support their education at home are more successful in school regardless of their grade levels or their parent's educational background and social class (Epstein, 1989; Froiland, Peterson, & Davison, 2013). Besides, PI increases the participation of the child in school activities and reduces educational differences between home and school. Similarly, PI has a positive role in children's literacy and language abilities (Carrol, 2013), and their external and internal motivation (Mccollough & Ramirez, 2010). Besides of contributing to their socio-emotional development (Li & Rao, 2000), PI reduces children's behavioral problems (El Nokali, Bachman, & Votruba-Drzal, 2010), enhances self-esteem (Fagbeminiyi, 2011), school readiness and cognitive development of preschool children (Weiss, Caspe, & Lopez, 2006).
- *Benefits for parents:* Getting involved and undertaking a more active role in their children's lives and in the community positively affect parents as well (OBADER, 2013; Ward, 2009). Participating in their children's education process provide parents

with the opportunity to develop their parental skills (Epstein et al., 2009). Indeed, PI may increase parents' self-confidence and satisfaction in terms of parenting (Hornby, 2011). Indeed, families who learn more about their children could get to know them better in the social environment. Parents who could see the teacher's interaction with their children have information about which behavior is more appropriate for their age. They could meet other families and learn that they have common problems and experiences with them (Epstein et al., 2009; OBADER, 2013).

- *Benefits for educators*: An effective PI may lead to an improvement in relationship between parents and the teacher, in teacher's motivation, and in school climate (Hornby, 2011). Teachers have more detailed information about their children's previous experiences. They gain a better understanding of the interests and needs of children and their families and could make changes in the program when necessary (OBADER, 2013).

As explained in the above subheadings, PI has the potential to provide contributions to not only the child, but also the teacher, and parents. Due to these possible contributions, PI takes also a wide place in the current Turkish ECE curriculum.

2.5.4.1 Family Support Education Guide Integrated with ECE Program (OBADER)

The "*Family Support Education Guide Integrated with ECE Program*" is prepared by Turkish MoNE in 2013 in order to present importance of family education and involvement to development and education of preschool children. This program also presents preschool teachers with some examples and ways of including parents in the education and development process of their children. It is emphasized in OBADER (2013) that the education of the child is a shared responsibility between the early childhood institution and the parent. The sooner parents participate in the child's education, the more the child will gain. PI in education is also influential in enhancing the success of school and home, consolidating the knowledge and skills gained by providing continuity between school and home, and ensuring continuity in education (OBADER, 2013).

According to this program, parental education includes the following seven primary goals. These goals which also guided this study while determining parent-related learning objectives of the intervention are as follows;

- To explain the importance of preschool education to parents
- Ensure that parents help their children during the school adjustment process

- Ensure that parents have information about their children's development, identify developmental characteristics by age group, and support their children
- To maintain healthy communication between family members
- Ensure that children learn different ways of organizing behavior and habits
- To ensure that parents adopt the educational attitudes and behaviors in schools
- Providing parents with educational attendance at school (OBADER, 2013).

In addition to these main objectives, OBADER incorporates some ethical and practical principles that should be considered by educators and researchers in parent education. According to these principles, socio-economic and cultural characteristics of the parents should be considered. Similarly, volunteering and confidentiality should be provided in order to be successful in parent education. Communication with family members should be made in a respectful and open manner considering human rights. Likewise, educators and researchers should be honest, patient and fair in their work with parents. Child development and education principles and disciplinary approach should be encouraged to take anti-violence child education into account when considering children's rights. Finally, parents should be encouraged to recognize their strength in their children's education and development process (OBADER, 2013).

OBADER also includes some practical principles to be taken into consideration by educators. These principles include emphasizing the topic, aims, and importance of the meeting, calling the participants with their names, reacting participants without any bias, taking parents' opinions about the subject that will be studied, and then completing the lack parts. Moreover, posing questions to the participants and giving them explanatory examples while working with them, avoiding get off the point, and give misinformation, using the time effectively, and evaluating the sessions by means of evaluation activities constitute the other principles taking place in the program (OBADER, 2013). As in ethical principles, all these practical principles were guided by both the researchers and the teachers during the EDCPI parent training and activity implementation process.

2.6.5 The Role and Importance of the Parents in Their Children's Engineering Education

Parents can contribute to their children's engineering education in a variety of ways. Firstly, parents can stimulate their preschool child's interest in engineering. Indeed, parents' knowledge and understanding about engineering may be effective on their children's interest in this field (Dorie & Cardella, 2014). On the other hand, research shows that parents have insufficient engineering knowledge even though they have a positive attitude towards engineering (Yun et al., 2010). Secondly, parents can provide their children with learning opportunities by experiencing engineering concepts and competencies, and they can be models for their children if their job is engineering (Dorie et al., 2014). On the other hand, research shows that even engineer parents do not teach engineering to their children (Dorie & Cardella, 2013). Thirdly, since parents are one of the environmental factors affecting children's occupational interests (Yun et al., 2010) they can help their children to recognize engineering and develop positive attitudes as a career area (Dorie et al., 2014).

For preschoolers, effective learning is possible when they experience the problem-solving process with the cooperation of an adult who enables them to assume more responsibility in the task as they master the different components of the task (Murphy & Messer, 2000). In a well-designed engineering-focused PI activity, children find the opportunity to experience EDP and to develop their engineering skills under the guidance of their parents (Smetana et al., 2012). On the other hand, when parents contribute to their children's engineering education, this will not only be limited to the increase in engineering-related learnings or interest in engineering. Indeed, engineering education has the potential to improve learning and success in other STEM disciplines (Katehi et al., 2009). Therefore, when parents clearly comprehend their roles and duties in encouraging and supporting their children in science and engineering, they can support their children to learn more about science and to develop their skills in scientific practices (Gunning et al., 2016).

By considering the abovementioned key roles of the parents, giving parents the opportunity to participate in informal learning activities is an excellent way to learn together and solve engineering challenges for parents, teachers and children (Smetana et al., 2012). In fact, when parents are invited to inquire, plan, design and enhance together, they experience working like a professional engineering team and being involved in EDP. In this way, their perception of the designed world and the diverse fields of engineering improves, and they can be a good role model for their children in questioning and problem solving (Murphy & Messer, 2000). In addition, the experiences children obtain by means of the EDP enable families to comprehend that engineering content is useful for supporting learning in a meaningful and developmentally appropriate early childhood classroom (Neuman, 2014). Parents who have this understanding can support their child's learning in engineering at school by contributing to the knowledge of engineering through informal conversations, such as discussions that may occur while walking around the city. Moreover, at home, school, playgrounds, and museums, it is possible to see children who discover, construct, and restructure their environment as a result of their interaction. Indeed, children tend to play with various materials provided in both structured and unstructured environments, so the potential of such instances to the occurrence of observable engineering thinking should be considered and supported (Bagiati & Evangelou, 2016). In fact, early childhood period is the time when the child often asks “what, where and why” questions and tries to make sense of the world around him/her. A spontaneous interaction, such as posing a question to his/her parents during a car trip, can be an opportunity for a child to discover new engineering learning skills and can have long-term effects. For instance, during a car trip, a child may ask his/her parents how the bridge over which they passed can hold numerous vehicles. They can discuss how many vehicles the bridge could carry without breaking down and thus parents speaking on engineering can be a significant component in improving key skills and interest concerning engineering (Dorie & Cardella, 2014). These types of experiences give parents the chance to share their knowledge with the child and to highlight specific concepts to the child. In addition, making children identify examples of engineering in their daily life and at home and school and involving children and their parents into opportunities to practice the EDP at different contexts are also change preschool children’s possible misconceptions about engineering (Smetana et al., 2012).

Involvement of parents into their children’s engineering education process is fruitful not only for parents and children but also for preschool teachers. Preschool teachers who desire to integrate engineering and technology into the curriculum but do not feel confident enough in their abilities may need support of the parents (Bers, 2007). In fact, engagement of parents in the engineering activities in the classroom or at home serves as a facilitator for preschool teachers and motivates them to implement early engineering curriculum in their classrooms (Bagiati, 2011). In other words, an effective EEE bases on the collaboration among all the stakeholders of education (Bagiati & Evangelou, 2015) (see Figure 8).

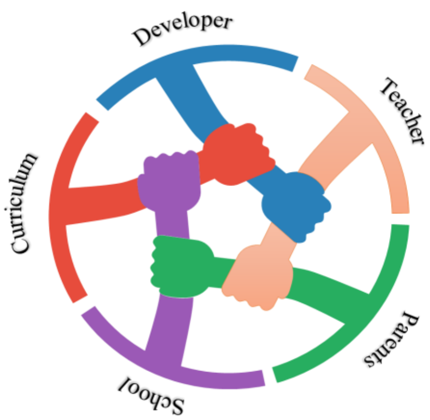

Figure 8 Stakeholders of the educational process affecting the implementation of a curriculum innovation in early childhood (modified from Bagiati & Evangelou, 2015, p. 126).

Even if the importance of their involvement in their children's early engineering experiences is very clear, parents may have low self-confidence to support children's learnings in STEM and need additional information and support in this area (McClure et al., 2017). In a similar vein, parents, as people who provide their children with informal learning opportunities, may not have enough information to connect engineering concepts with daily experiences. Indeed, contrary to math and science disciplines, engineering necessitates further awareness to make connections (Dorie & Cardella, 2014). At that point, parents may need suggestions about how they can transform daily-life experiences to a learning opportunity for their children and continue to support their children's curiosity in engineering within environments outside the school (Smetana et al., 2012). For this reason, sufficient amount of resources must be provided to parents to increase their awareness of the power of home activities in associating children's engineering education and their real life (Dorie & Cardella, 2014). In addition, research has shown that the learning environments surrounding children and the ability to reflect and to act as models for children during the daily routines and interactions of adults in these settings significantly enhance children's learning experiences. Therefore, adults in the children's environment, such as parents and teachers, should be able to consistently use these thinking skills as observable by children and be a model for them. Engineering design activities constitute an effective opportunity for parents, teachers and children to experience and display those higher-level thinking skills (Stone-MacDonald et al., 2015).

2.6.6 Barriers to Parental Involvement

The importance of PI in early childhood has been emphasized for many years in the literature and supported by findings from a wide range of studies. On the other hand, there is a clear gap between theory and practice and this gap may be caused by various reasons known as barriers to PI (Hornby, 2011).

The barriers were dealt with by researchers under different headings. For instance, as mentioned in the previous sections, Hoover-Dempsey and Sandler (1995) focused on factors that could be effective on parents' decisions regarding the involvement. According to them, some factors including parents' motivational beliefs, their perception of invitation, and their life context can be effective on their involvement. In a larger perspective, Hornby and Lafaele (2011) proposed a model and addressed PI barriers in four main areas in the light of the overlapping spheres framework of Epstein (2001). The first area of this model includes parents' individual characteristics involving their beliefs about the PI, current living conditions, perceptions of invitations and their class, gender, and ethnicity. The second area, which may be a barrier to PI, includes child-related factors such as child's age, skills, behavioral problems, disabilities and learning difficulties. The third area includes factors related to parent and teacher relationship, such as the differences in the agendas, in the attitudes and in the spoken language. The fourth area includes societal issues that may constitute a barrier to the PI such as demographics, history, politics, and economics. In addition to these two approaches, Canter and Canter (2001) identified some roadblocks for PI from the teachers' and parents' perspectives.

A closer look at the barriers, it is seen that parents' life conditions, their previous and current PI experiences, and their beliefs and understanding can be effective on their involvement (Wheeler & Connor, 2009). First, the beliefs of parents about their role in the education of their children (parent's role construction) is quite important (Hoover-Dempsey et al., 2005; Hornby, 2011). Unfortunately, as Keyser (2006) emphasizes, some parents may not even be aware that there is a place for the children's families at school. In fact, the possibility of actively and willingly involved in her/his child's education process is very lower for a parent who views her/his role as only getting the child to school (Hornby, 2011). On the other hand, when parents believe that their involvement is an important and needed part of their children's success, they become involved in the child's education process (Hoover-Dempsey & Sandler, 1997). Secondly, the beliefs of the parents about their own skills to contribute to their children's school success (self-efficacy) are very important to PI (Ho & Kwong, 2103; Murray, Dwyer, Rubin, Knighton-Wisor, & Booth-LaForce, 2014). In fact, parents' low self-efficacy might result from their bad experiences with the prior school of their children, their fear not to communicate with the teacher in an effective way due to the difference in their first language (Hornby, 2011). In addition, some parents may not be sure that they have something valuable to contribute to their children's education due to their limited education or literacy level (National Parent Teacher Association [National PTA], 2001). On the other hand, parents sometimes want to support their children's education and contribute to the school, but they have no idea how to do. In other words, some parents are in the need of guidance and reinforcement to be involved (Canter & Canter, 2001; National PTA, 2001).

Another factor that might serve as a barrier to parents' involvement in education is their life context (Hornby, 2011). Researches revealed that parents' heavy workloads, their responsibility to look after the other members of their family (Ho & Kwong, 2013), and being a single or adoptive parent were effective on their involvement (Baker, Wise, Kelley, & Skiba, 2016). According to the researches, working parents, single parents, and parents who have other children may be less involved in school-based activities (Baker et al., 2016; Fan, Li, &

Sandoval, 2018). In addition to these factors, due to some other factors related to their life contexts such as poverty, work stress, and illness, parents may feel overwhelmed and do not have the sufficient time and energy to be involved in their children's educational process (Canter & Canter, 2001). This limited participation can cause parents to ignore the education of their children, lead to conflicts in the objectives and agendas of schools and parents, and cause to be unaware of the activities and event organized at the school (Baker et al., 2016; Fan et al., 2018).

In addition to their beliefs, self-efficacy, and life conditions, parents' perceptions towards the invitations for their involvement are effective in their decisions (Hoover-Dempsey & Sandler, 2005). In fact, parents' perception that teachers are not willing to involve parents in the educational process serves as the biggest roadblock to PI (Hornby, 2011). The perception that parents are unwelcomed in the school environment can arise through staff interactions and approaches to the parents (Murray et al., 2014; National PTA, 2001). Moreover, the physical appearance of the school may indirectly convey this message to the parents (National PTA, 2001). On the other hand, when especially parents who have a passive role construction and low self-efficacy perceive that they are welcomed and valued in the school environment and that their involvement is expected by the staff, this may motivate them to be involved (Hoover-Dempsey et al., 2005).

Barriers to PI are not only related to the parents. The relevant literature has also pointed out that there are many barriers related to the teacher (Antoine, 2012; Hornby, 2011; Keyser, 2006; Wheeler & Connor, 2009). Keyser (2006) summarizes these barriers in four items. According to him/her, the first teacher-related barrier is teachers' insufficient experience and education regarding the PI. The second barrier is teachers' lack of time to obtain more information about families and lack of the appropriate place to conduct their meetings. The next barrier is related to teachers' inadequate experience and education to deal with the faced challenges due to the cultural diversity. The last barrier is related to some attitude and beliefs of the teacher. These are the low self-confidence, inadequate knowledge of child development, feeling uncomfortable working with parents, and ignoring families (Keyser, 2006).

In parallel with these four items, research revealed that teachers' belief that PI's aim was to minimize the behavioral problems of the child in the classroom prevented PI (Antoine, 2012). Similarly, some teachers might have low expectations of PI and this might be a barrier to the PI (Canter & Canter, 2001). In fact, as Keyser (2006) pointed out some very few of the teachers are able to establish a strong relationship with the parents, and most of them experience difficulties in this regard. Some teachers feel themselves capable of working with children, but their confidence is low when it comes to collaborating with parents. Some fear to be criticized by the parents and some of them do not know where they should begin.

To summarize, it is possible to a wide variety of barriers when looked at from the perspectives of the parents and teachers. All in the relevant literature to reveal roadblocks and facilitators of PI is based on the aim to identify factors affecting the decisions on PI (Murray et al., 2014). In fact, clarification and understood of these barriers can enable to develop effective PI practices (Hornby, 2011). In a similar vein, in this study which aimed to develop a STEM-based engineering design curriculum for the involvement of the parents in their children's education process, barriers and facilitators of the developed curriculum were explored from teachers and parents' viewpoints.

2.7 Curriculum Development

As stated earlier, one of the aims of this study is to develop an effective and practical engineering design curriculum to be applied in early childhood classrooms with the involvement of parents. Therefore, in this curriculum development study, in addition to the literature on EEE and PI, the literature on curriculum development was also focused. In this respect, the definition of curriculum, curriculum ideologies, various curriculum models used in ECE, and components of the curriculum were explained in the following subsections.

2.7.5 Definition of the Concept of Curriculum

The term of curriculum is used by everyone who treats the subject of education, schools, or teachers. On the other hand, a handful of people think about what it means, what is needed to design a good curriculum, what it is for, and what serves as the right basis for the preparation of the curriculum. However, it is difficult to make a common and clear definition of the curriculum (Null, 2011). In fact, it is possible to encounter a wide variety of definition of curriculum from very broad ones such as "all the efforts of schools" to very narrow one such as "content" (Walker, 1990; Wang, 2001). As van den Akker (2013) emphasized, while there are many definitions in the literature about a concept (as in the curriculum), it is difficult to focus explicitly on the essence of this concept. In such cases, examining the concept in terms of its etymological origins helps to understand it. The curriculum which is a Latin word means a "course" or a "track" to follow. When it comes to its meaning in the field of education, in the most general sense the curriculum can be defined as the official products and documents guiding what is to happen in the classroom (Mueller, 2012). In its briefer definition, curriculum is "a plan for learning" (Taba, 1962, p.11). This brief description (reflected in relevant terms in various languages), is in fact limited to the essence of all other definitions and allows all kinds of detailing for different educational levels, contexts, and representations (van den Akker, 2013). In a more detailed definition, Kagan and Kauerz (2012, p.2) define curriculum as “the content of what is taught and what is learned.” In fact, curriculum is about addressing a topic, preparing it to use it in the classroom and fulfilling it to make a lasting impression on students. In this context, curriculum is the basis of education since it is related to what is to be taught, and it combines thought, purpose, and action (Null, 2011).

In this study, the curriculum definition by NAEYC was used. NAEYC (2008) defines curriculum as a written plan that includes the learning goals about the knowledge and skills expected to be acquired by children, and the learning experiences used to help them achieve these goals. Learning objectives consist of knowledge, skills and dispositions that children are expected to acquire (Bredekamp, 2016).

In addition to these various definitions of the curriculum mentioned above, it is possible to encounter three different curriculum representations in the literature, namely “intended”, “implemented” and “attained” curriculum. The *intended curriculum* includes the ideal curriculum which refers the rationale or main philosophy which is the basis of a curriculum besides of the formal/written curriculum which means to intentions implied in curriculum materials and documents. The *implemented curriculum* includes the perceived curriculum (users’ interpretations, especially teachers' interpretations) as well as the operational curriculum (as implemented in the actual teaching-learning process). Finally, the *attained curriculum* is composed of the experiential curriculum, which refers to the learning experiences from learners’ perception, as well as the learned curriculum which means the learning outcomes achieved (McKenney, Nieveen, & van den Akker, 2006; van den Akker, 2013).

To sum up, the relevant literature provides different definitions and representations of curriculum. In the context of this study, the curriculum was defined as learning objectives and indicators including engineering knowledge, skills, feelings, and dispositions, and the learning activities through which children are intended to reach these objectives. All these components with their forms determined before the implementation of the curriculum represented the intended curriculum in this study. On the other hand, findings of the current study reflected the attained curriculum.

After the information of what curriculum means, various curriculum ideologies taking place in the literature and the ideology which provided a basis for this study were explained in the following subsections.

2.7.6 Curricular Ideologies

Curriculum designs are based on four main ideologies that shape the curriculum practice (Schiro, 2013). Each of these ideologies on curriculum has different beliefs related to the kind of knowledge to be taught in schools, children's innate nature, what education in school includes, the ways of teachers instructing children and children's evaluation (Schiro, 2013). Table 7 summarizes each ideology.

The four curriculum ideologies, each based on a long history, are known by various names in the literature. For example, learner-centered ideology has emerged in the last century as progressive education, child-centered education, DAP, and constructivism (Schrio, 2013). Like a large body of contemporary curriculum models and approaches in ECE around the world (e.g. Reggio Emilia, Montessori), the curriculum developed within the scope of this study grounds on learner-centered ideology. Indeed, this study is dominated by the idea that the educational process should be a child-centered process in which teachers and parents facilitate the process of structuring knowledge, and that activities should be shaped based on children's needs and interests.

In addition to these curricular ideologies, in the curriculum development literature, some curriculum models and approaches shed light on curriculum development studies in ECE. In the following sections, firstly it is presented that what curriculum model, curriculum approach, and curriculum framework mean. Then, the main curriculum framework underlying the curriculum designed in this study is introduced.

2.7.7 Curriculum Model, Curriculum Approach, and Curriculum Framework

In the previous section, some curriculum ideologies are presented. In this section, some curriculum models and approaches developed in the light of these ideologies in ECE are briefly introduced.

In ECE, the curriculum should be based on a coherent and intertwined curriculum model. The overall objective of a curriculum model is to design educational objectives, planned interactions, course content, materials, resources and evaluation processes (Schweinhart, 2017). Indeed, a curriculum model is a research-based and idealized representation of what teaching and learning should be and how it should be realized (Bredekamp, 2016). Early childhood educators have searched for child-centered curriculum models for centuries as an alternative to teacher-centered education (Schweinhart, 2017). The widely used curriculum models in ECE are the Montessori method, High-Scope curriculum, and Creative Curriculum (Goffin, 2000; Dodge, 2004; Schweinhart, 2017). When compared

Table 7

Curricular ideologies

Ideology	***Explanation***
The Scholar Academic Ideology	Throughout the centuries, culture accumulates substantial knowledge which can be found at universities as organized into disciplines. The aim of education is to assist children to acquire this accumulated knowledge, in other words, the academic disciplines, by learning their contents, ways of thinking, and conceptual frameworks. The role of teachers is to understand in depth their discipline and to introduce that discipline to children in a clear and accurate way. The curriculum should be constructed to reflect the essence of the discipline (Schiro, 2013). According to this view, children are blank pages to fill with knowledge, and learning takes place through the transfer of knowledge from the teacher to the child (McLachlan, Fleer, & Edwards, 2010).
The Social Efficiency Ideology	The goal of schooling is to educate young people as adults who will contribute to society in the future and thus respond efficiently to the requirements of society. The defenders of this ideology believe that the essence of the children bases on their capabilities and in the activities they can perform. Young people learn to perform the functions necessary for social productivity through education. The role of the teachers is to carry out instruction by choosing and utilizing educational methods developed to assist children to acquire behaviors predetermined by the curriculum. The explicitly identified behavioral objectives guide the instruction, and learners may need to perform a lot of practice to gain mastery in skills (Schiro, 2013). In fact, in this ideology, school is like a factory and students are like raw materials. The adult is a finished product from the factory and the teachers are the workers who operate the machinery in this factory. The task of the teacher is to determine what the consumer expects from a finished product and what is the most effective way to produce this product. In this ideology, the teacher is the person who doesn't design the curriculum but practice it. Thus, the curriculum is protected from the unpredictable individual teaching skills. Learners are assessed based on changes in their behavior and changes that are not observable are not taken into consideration (McLachlan et al., 2010).
The Learner-Centered Ideology	This ideology derives its origins from John Dewey's (1915) idea of "schools of tomorrow" and is the hallmark of ECE models such as Montessori and Reggio Emilia. Education should focus on the individual needs and concerns of learners, not on the needs of the society, teachers or school administrators or on academic disciplines (McLachlan, 2010). Schools are considered as enjoyable places in which learners naturally develop in accordance with their own nature. The aim of education is the development of each learner in accordance with their specific social, emotional, cognitive and physical characteristics. (Schiro, 2013). The defenders of this ideology put learners in the center of the curriculum, and learner's interactions with her/his physical, social, and intellectual environments encourage her/his growth and development (Cohen, 2017). For this reason, learning is considered as a function of (meaning constructing) of the learners' interaction with his/her environment. Since the interaction of each individual with his/her environment is supposed to be unique, the outcomes of learning are assumed to be unique to the learner. Teachers are not the transmitter of the knowledge, on the contrary, they are responsible for carefully observing children and creating those environments and contexts that will encourage the growth of students in

Table 7

(continued)

	the process of constructing meaning for themselves (McLachlan et al., 2010; Schiro, 2013). From the perspective of this ideology, the focus of the curriculum is to provide children with hands-on experiences, and an integrated curriculum based on the understanding of children's education as a whole. The basic theory used by the curriculum developers adopting this ideology is Piaget's constructivist theory which regards children as active learners who develop cognitively through interactions with the physical world around them. Similarly, social constructivist understanding based on the theories of Vygotsky has also been represented in this ideology (e.g. Developmentally Appropriate Practices [DAP]) (McLachlan et al., 2010).
The Social Restructuring Ideology	This ideology is based on the belief that society is threatened with many problems such as racial, social and gender, and that the treatment of these social problems is education (Schiro, 2013; McLachlan et al., 2010). In fact, this ideology defends that education should aim at facilitating the establishment of a new and fair society that provides the utmost satisfaction to all members. The advocates of this ideology see education as a social process that enables the restructuring of society. They think that cultural factors shape human experience in the strongest way and assume that social experiences are the determinants of meaning in people's lives (Schiro, 2013). The experiences involving children emotionally and intellectually is the basis of learning, and children are seen as meaning-makers who comprehend, interpret and regulate their own facts. In our global community, a very limited number of ECE curricula are based on social reconstruction, but as an element of their worldview on teaching and learning, there are early childhood educators who have adopted this ideology in their center (McLachlan et al., 2010).

to the curriculum model, a curriculum approach includes less detail. The most extensive curriculum approach used in ECE is the Reggio Emilia.

The curriculum models and approaches provide curriculum developers and implementers with a frame about the curriculum content. On the other hand, the curriculum framework guides for planning a curriculum or choosing a curriculum model (Bredekamp, 2016). The consistent focus required to plan children's experiences is achieved through a clearly defined curriculum framework. Such a framework enables adaptations and changes to ensure that all children have access to the curriculum (NAEYC, 2008). When it comes to ECE, one of the widely used curriculum frameworks is Developmentally Appropriate Practices (DAP). DAP aims to guide stakeholders making decisions on education and development of young children (Bredekamp & Copple, 1997) and provides them a framework for the best practice (NAEYC, 2009, p.1). In the current study, DAP shed light on the researcher to determine the main characteristics of the designed and developed curriculum within the scope of the study. In fact, one of the main characteristics of the designed curriculum was identified as developmentally appropriateness and the requirements of a developmentally appropriate curriculum enabled the researcher to determine both the content and implementation process of the curriculum. The following section presents information about DAP which is one of the underlying frameworks of this study and its requirements.

2.7.7.1 Developmentally Appropriate Practices

DAP is a position statement related to developmentally appropriate practice for ECE published by NAEYC in 1986 and 1987 (Bredekamp, 1987). Having become the most influential document in directing ECE since its publication, DAP has encouraged practitioners in ECE to make changes in their classroom implementations and researchers to empirically investigate the impact of developmentally inappropriate and appropriate implementations on children's development (Hart, Burts, & Charlesworth, 1997). DAP shed light on this study in the matter of the principles that should be considered in the construction of a curriculum for preschoolers and the characteristics of an effective curriculum. The DAP recommends that the following issues be considered in the preparation of a curriculum for preschoolers:

- The curriculum should be developmentally appropriate; in other words, the learning outcomes in the curriculum should consist of appropriate expectations for many children in the age range that the curriculum will address (Bredekamp, 2016).
- The curriculum should ensure that children are physically, cognitively, socially and artistically active and engaged (Gestwicki, 2014).

- The curriculum should be culturally and linguistically appropriate. Indeed, the curriculum should support the child's cultural identity and the language spoken at home and recognize the child's ability (Bredekamp, 2016).
- Main desired learning outcomes (goals which are important to learning and development of children) should be determined, clearly articulated and understood by overall stakeholders of the education including teachers, parents, and administrators (NAEYC, 2009).
- The curriculum should be evidence-based and organized around the principles of child development and learning (Gestwicki, 2014).
- The important content should be learned via investigation, play, and focused and purposeful teaching. Teaching strategies should be chosen in accordance with the child's age, developmental abilities and disabilities, language and culture (Gestwicki, 2014).
- The curriculum should be structured on prior learning and experience in terms of both content and practice (Gestwicki, 2014).
- The curriculum should be comprehensive. It should cover both diverse developmental fields (cognitive, language, emotional, social, and physical) and different content areas (e.g. mathematics, science, literacy, and arts) (Bredekamp, 2016).
- The subject area content of the curriculum should be validated by content standards proposed by field professionals (Bredekamp, 2016)
- The curriculum should be useful in terms of reaching a wide range of learning outcomes in accordance with research for children or plans based on obtaining such evidence (Getswicki, 2014).
- The curriculum should be adaptable to address the learning needs and characteristics of pre-school children work with. Indeed, developmentally appropriate practice enables teachers to be flexible in designing and practicing curricular experiences in preschool classrooms (NAEYC, 2009).

Besides of all these characteristics, DAP emphasizes curriculum integration. Indeed, DAP defends that an integrated curriculum addressing all developmental fields (intellectual, social, emotional, language, aesthetics, physical) and curricular content from diverse disciplines should be constructed for preschool children (NAEYC, 2009). Such a curriculum depends on the integration of content from diverse disciplines by means of learning experiences such as themes, play, and projects. In this way, children may have the opportunity to develop their knowledge of concepts and to make connections among different disciplines

(Bredekamp & Copple, 1997). In this respect, the DAP is also an appropriate framework for curriculum integration that underlies STEM, the educational approach adopted in this study.

In addition to the adopted curriculum framework, other important points in a curriculum development study are the used curriculum development model and the paradigm adopted during this process. The following section presents the main five-steps curriculum development model and main paradigms shed light on how this model will be conducted.

2.7.8 Curriculum Development Models

The focus of curriculum development is to improve and innovate education. In the literature, it is possible to encounter various models utilized in curriculum development process. On the other hand, all these models depend on five key interactive activities (analysis, design, development, implementation, evaluation) (Thijs & van den Akker, 2009, p.15) (see Figure 9). The curriculum development approach adopted by the curriculum developer determines how these five key activities are carried out (Thijs & van den Akker, 2009). Visscher-Voerman and Gustafson (2004) identifies four widely used curriculum development paradigms in education: a) instrumental; b) communicative; c) pragmatic; d) artistic. These paradigms are briefly summarized in the following headings.

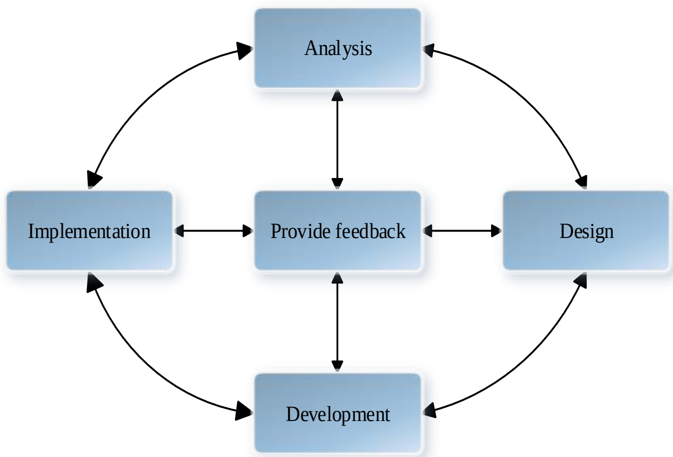

Figure 9 Key activities experienced in curriculum development process (adapted from Thijs & van den Akker, 2009, p15).

- *Instrumental Paradigm*

Instrumentalists believe that systematic working and logical reasoning are the principal factors to ensure the best solution (Visscher-Voerman & Gustafson, 2004). In line with comprehensive analysis, explicit and measurable learning objectives are identified for the curriculum development process, and the design process is shaped by considering these objectives (planning by objectives) (Thijs & van den Akker, 2009). Tyler (1949) who is the representative defender of this paradigm proposes a rational and linear framework called Tyler rationale involving four questions for curriculum design and instruction: What are the educational objectives to be achieved by the school; what learning experiences can be provided that make it possible to achieve these objectives; how can these experiences be efficiently organized; what is the way to determine whether these objectives have been achieved? This approach has been criticized for its strong emphasis on achieving predetermined objectives by limiting the flexibility needed to adapt to the ever-changing needs of curriculum users and the increased insights of curriculum designers (Thijs & van den Akker, 2009).

- *Communicative Paradigm*

This approach focuses on the role of close interaction and communication between curriculum developers and other relevant persons in the development of all educational products, including in the curriculum. Therefore, it is very important to establish relations with stakeholders and to gather the inputs of curriculum developers and other involved people (Thijs & van den Akker, 2009). According to this approach, a good design must be in accordance with the standard discussed and agreed by the people in the design team and other relevant stakeholders (Visscher-Voerman & Gustafson, 2004). A clear and well-known example of this paradigm is the model proposed by Walker (1990). Walker aimed to create a naturalistic model to reflect curriculum development practices and proposed a three-phases (platform of ideas, deliberation, and design) deliberative model for this purpose (Thijs & van den Akker, 2009). The platform phase is based on the unification of individuals to discuss their beliefs and goals about the ideal curriculum. In the deliberative phase, the focus is on how the formulated beliefs are utilized to assess real situations and possible action plan. The design phase involves activities will be carried out for the realization of beliefs and goals (Wang, 2001). This approach is criticized because of the possibility of negotiation processes being too time-consuming and inconvenient and not to result in consistent products (Thijs & van den Akker, 2009).

- *Artistic Paradigm*

The artistic paradigm lays emphasis on the designer's creativity. This approach assumes that design process is subjective and directed at the personal opinions and expertise of the designers. It is important for designers to creatively anticipate the unique qualities of the target audience, rather than to follow through objective criteria or specific procedures. Eisner (2002), one of the representatives of this approach, argues that important design decisions should be taken by teachers and teachers should make decisions on the curriculum in accordance with their vision and experience by predicting the situation as it is. The disadvantage of this approach is that the products are generally narrow because they focus on a specific use context and are based on the designer's personal views (Thijs & van den Akker, 2009).

- *Pragmatic Paradigm*

The pragmatic paradigm argues that the products are created as a result of the rapid creation, testing and revision of several prototypes. If a product has been evidenced to be practical and effective for users in a specific context, it is possible to say that this product is good (Visscher-Voerman & Gustafson, 2004). The essential activity is formative evaluation, and design and evaluation activities are performed interactively. The first draft of the possible ultimate product is developed as a result of a short preliminary study consulted with experts and literature. This first prototype, in which design specifications are visualized, is developed into a complete form of the product after a series of designs, evaluations, and revisions. The prototyping of the design, taking into account the wishes and possibilities of the users, aims to increase the practical usability and ownership of the product (Thijs & van den Akker, 2009).

In the present study, the pragmatic paradigm was adopted as a curriculum development model due to two reasons. First, at the beginning of the process, it was unclear how to design an engineering education curriculum based on parental participation for preschool children, what the curriculum components would be and what kind of support would be needed for teachers wishing to implement this curriculum. The pragmatic strategy and the prototyping cycles proposed by this strategy could help the researcher make the design specifications explicit and to obtain results closer to the optimal product in each successive cycle. Secondly, this approach could help to increase the practical applicability of the curriculum to be developed within the framework of the study by allowing users to evaluate the curriculum.

After defining the program development model and paradigm, another important consideration is the components constituting the curriculum. In the following section, some curriculum component frameworks are introduced, and the components of the curriculum designed and developed in this study are described.

2.7.9 Components of A Curriculum

As aforementioned, identification of curriculum components is another important step of the curriculum development process. Most curricula include learning goals related to the knowledge and skills expected to be achieved by the children, learning experiences designed in connection with these learning goals, daily plans and routines where activities and learning opportunities are integrated, and the availability and arrangement of learning materials for children (NAEYC, 2003). McLachlan, Fleer, and Edwards (2010) list these components that should be included in a curriculum applied in any educational setting from early childhood to higher education:

- *Statements on learning goals, objectives, or outcomes* (what is intended to be achieved with this curriculum; what kind of learning outcomes would be expected to be achieved as a result of attending in the application of this curriculum?)
- *Context, domains or topic* (what will be included in or excluded from the curriculum?)
- *Teaching methods or approaches* (which methods or procedures will be utilized in order to reach the learning objectives or outcomes of the curriculum?)
- *Assessment and evaluation* (How will it be known that the learning objectives and results of the curriculum have been achieved?)

van den Akker (2013) provides a more detailed framework for the components of the curriculum. According to this framework, the curriculum has ten basic components and ten fundamental questions addressed by these components. As in the spider-web model presented by van den Akker in 2004, the curriculum components are held together by a sensitive structure. The rationale at the center of the model holds all the other components which are learning goals, curricular context, learning activities, the role of the teacher, materials, and sources, location, time, group, and assessment. The point highlighted in this spiderweb metaphor is that the emphasis of the components can change over time, but any major change in balance can pull the integrity out of alignment and long-term imbalance will bring on break on the system. Therefore, the balance and connection among these ten curriculum components should be taken into account by researchers who aim to develop, redesign, or modify curricula (McKenney et al., 2006) (see Figure 10).

The curricular web model proposed by van den Akker (2013) shed light on the design of the components of the curriculum developed in the current study. How and in which stage this framework is used in the design of the curriculum is explained in detail in the methodology chapter. On the other hand, in this study, the four main components of learning proposed by Katz (1999) played an important role in determining the rationale that holds all other components together in the web model and forms the basis of the curriculum. In the following section, these four main dimensions of learning in the preschool period are presented.

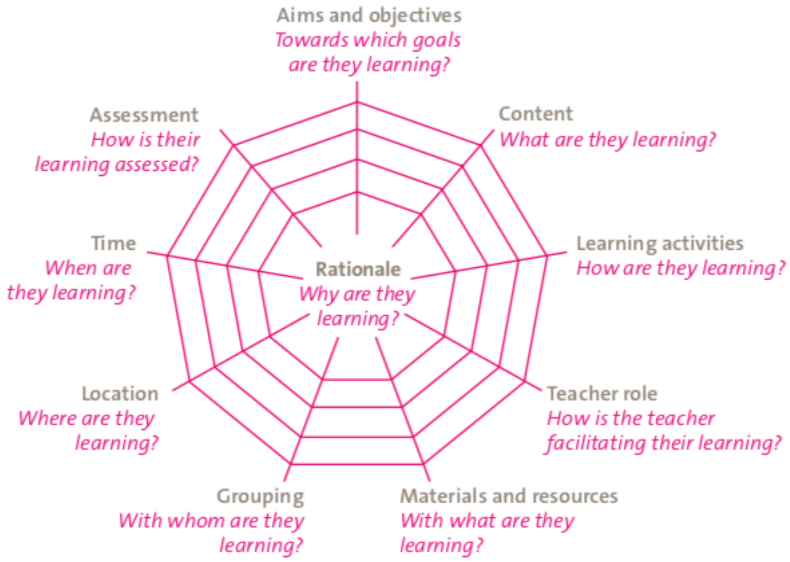

Figure 10 Curriculum components and curricular spiderweb (van den Akker, 2013, p. 59).

2.7.9.1 Dimensions of Learning in the Preschool Period

In the current study, the proposed curriculum was structured around four dimensions of learning identified in the light of the relevant literature. As Katz (1999) stresses, a curriculum for preschoolers should focus on some learning goals under the dimensions of knowledge, skills, dispoisitions, and feelings. Similarly, National Association for the Education of Young Children (NAEYC, 2003) emphasize that a perfect instruction should be built on children’s existing knowledge and abilities, and should provide them knowledge, skills, and dispositions to ensure life-long learning. By starting from this viewpoint, EDCPI includes some engineering related learning outcomes shaped under these four dimensions. While the knowledge dimension includes learning outcomes about engineering, the skills dimension includes learning outcomes about applying engineering. In addition, dispositions include some habits of mind related to thinking, and lastly the feelings dimension includes the way of children's feels about learning in engineering. Hence, all activities in the curriculum are designed to give children these learning outcomes identified in the light of literature (Katz, 1993; NRC, 2012; Stone-MacDonald, 2015).

- *Knowledge*: As the first dimension, in early years, knowledge includes information about facts, concepts, relations (e.g. cause and effect, part and whole), ideas, vocabulary, and other cultural aspects. The ways of acquiring such knowledge for children are the answers given by someone to their questions, and another person’s definitions and explanataions with regards to the events. In addition, the best way to make sense of the knowledge for a child is to construct his/her knowledge with active and direct observation, and personal experiences (Katz, 1999; Katz & Helm, 2001).

- *Skills*: Skills are small action units that emerge in a comparatively short time and are easily observable or deducible (Katz, 1999). Early childhood is the period when a variety of basic skills and the way of applying these skills are learned. Physical, verbal, social skills, basic academic skills such as counting, drawing, reading, and measuring, basic scientific and technical competences such as usage of technical and scientific tools, observation and research, and some social skills such as collaboration, discussion, negotiation and team-work are only a few of the skills learned by children in early childhood (Helm & Katz, 2001). According to Katz (1999), skills can be acquired through direct instruction and observation-based imitation, and can be improved by applying to the real situations, practicing, repeating, and guidance.
- *Dispositions*: Katz (1993, p.16) defines dispoisitions as "…a pattern of behavior exhibited frequently and in the absence of coercion, and constituting a habit of mind under some conscious and voluntary control, and that is intentional and oriented to broad goals." Curiosity, creativity, being friendly or commanding, being generous or stingy are about dispositions rather than about skills or knolwedge. For instance, having writing skills is different from having a tendency to select authorship as a career (Katz, 1995). Similarly, the term of disposition is different from the term of trait. Katz and Raths (1985) emphasize this difference and state that a disposition refers a trend in the behaviors of a person rather than his/her emotional status. Hence, some terms such as honesty, braveness, and ambition are dimensions of personal traits of a person and his/her emotional management. On the other hand, dispositions can be utilized to designate behaviors and characterize these behaviors' frequency. For instance, a child who often and typically interacts with the environment by exploring, investigating, and posing questions about it can be considered as disposed to be curious. On the other hand, all dispoisitons are not desirable. For instance, a child can have a dispoisiton to be complainant (Katz, 1993). Majortiy of our dispositions are innate and are probably quite robust in early childhood years. For example, almost all children, regardless of the demographic characteristics of their families, tend to be curious, make sense of their experience, and be experimental (Helm & Katz, 2001). According to Katz (1993), knowledge and skills are addressed by academic goals while dispositions are addressed by intellectual goals. Some of these intellectual goals

related habits of mind can be dispoisitions to make sense of experiences, to make a prediction and compare the prediction with the real circumstance, to explore, to seek the truths, to be comprehend the consequences of acts, to be persistence in prodcing solutions to the problems, to make predictions about cause-effect relations, and about other people's wishes and feelings.

- *Feelings*: For the learning, feelings refers how the child feels about learning (Helm & Katz, 2001). Some feelings like fear are inborn, but some of them such as security, confidence, and belonging are learned. Similarly, some feelings such as feelings about school, teacher, peers, and about learning are learned in early childhood (Katz, 1993).

CHAPTER 3

METHODOLOGY

The review of the relevant literature presented issues regarding the rationales of integrating engineering education into early childhood education (ECE), the need for a developmentally appropriate engineering design curriculum which includes parents in their children's engineering education process, and curriculum development. Accordingly, the current study sought to propose a new way of integrating Science, Technology, Engineering, and Mathematics (STEM) into preschools and of parental involvement (PI): *STEM Based Engineering Design Curriculum for Parental Involvement in ECE (EDCPI)*. Hence, the general aim of the study was to design and develop the EDCPI and explore the factors to be considered while designing and developing such an engineering design curriculum including various curricular components (e.g. learning objectives, learning contents, and assessment tools). In line with this aim, the focus of this chapter is the research design of the current study and the methodology presenting how this research design was used throughout the study. Thus, in this chapter, the main phases of design-based research (DBR), the research design utilized in the present study, are explained from the curriculum perspective. In addition, information about the participants, curriculum development and implementation processes, and data collection and analysis procedures are explained to clarify the methodology. Finally, trustworthiness, assumptions, and (de)limitations of the study are addressed.

3.1 Research Design

The purpose of the current study was to design and develop EDCPI as a tool for integrating engineering design process (EDP) into instructional practice through the parental involvement to enhance preschool children's learning in STEM, specifically in engineering. In parallel with this purpose, the current study aimed to investigate the characteristics of an effective and practical STEM-based engineering design curriculum addressing preschoolers, their parents, and teachers. In this regard, this study also aimed to investigate the contributions of such a curriculum to preschoolers, teachers, and parents.

Considering the aims and nature of the study, DBR was used in this study to design and develop the EDCPI and determine its main characteristics. Hence, in the subsequent section, the nature and characteristics of DBR are explained briefly in order to clarify the rationale underlying the preference to employ this research design in the current study.

3.1.1 Design-Based Research

DBR has been utilized for many years, but referred to by different terms in the relevant literature, some of which are "*Design experiments*" (Brown, 1992; Collins, 1992), "*formative research*" (Newman, 1990), "*developmental research*" (Richey & Klein, 2005), and "*design research*" (Dai, 2012). Even though there are some differences in their approaches, they have many common characteristics (Kennedy-Clark, 2015).

In general terms, DBR is defined as "the study of learning in context through the systematic design and study of instructional strategies and tools" (Design-Based Research Collective, 2003, p. 5). More specifically, DBR is a process which combines design with scientific methods, thus enabling researchers to produce helpful instructional interventions and useful theory for solving personal and collective educational problems (Anderson & Shattuck, 2012). Indeed, in DBR, an iterative study process which not only assesses an innovative intervention but also intends to systematically strengthen the innovation is emphasized (Plomp, 2013). In this way, DBR not only creates a practical product that is designed and developed throughout the research process, but also contributes to the development of the theory. From this aspect, in educational settings, DBR ultimately contributes to reducing the gap existing between educational research and real-life practice (Lagemann & Shulman, 1999).

As stressed in Design-Based Research Collective (2003), DBR should possess some primary characteristics. Firstly, in a good design research, the principal aims of designing learning settings and establishing learning theories are interlocked. Secondly, development and research happen by means of iterative cycles of "design, enactment, analysis, and redesign" (p. 5). Thirdly, design studies should result in sharable theories, which contribute to both practitioners and other educational stakeholders with respect to communicating associative implications. In addition, the research study should emphasize the interactions between learning-related issues, as well as the successes or deficiencies in order to lead a better design. Fifth, developing such explanations is based on methods that document and link to conclusions concerning the enactment process.

Researchers have utilized DBR for various purposes in the field of educational research. As highlighted by Plomp (2013), in validation studies, DBR entails design and development of educational interventions (e.g. learning processes, learning settings) with the aim of developing or validating theories related to the implemented intervention and the methods by which it is designed. On the other hand, in development studies, DBR involves the systematic design, development, and evaluation of instructional interventions (e.g. curricula, educational materials, products, systems, learning processes and environments) proposed as a solution to complicated educational problems and enables us to understand the design and development process of the intervention and its characteristics. In fact, development studies, in the light of the information obtained from previous research and relevant literature, involve designing and implementing effective and practical interventions by attentively examining consecutive prototypes of interventions in the intended contexts and by collaborating with practitioners (Plomp, 2013). Since the current study aimed to enhance the practice by designing and developing a STEM-based engineering design curriculum for PI in ECE as an intervention, it could be classified as a development study.

DBR provides educational researchers with a process in which researchers design and examine interventions addressing real-world problems in order to produce practical and efficacious interventions and produce a theory to guide the design. From this aspect, DBR is important because it adopts neither solely interventions nor solely theory. Indeed, the theory obtains its goals from implementation, and implementation draws its strength from the theory (Easterday, Rees Lewis, & Gerber, 2014). Hence, DBR goes beyond solely designing and testing specific interventions; it enables being embodied by theoretical assertions on teaching and learning by means of interventions and represents a commitment to understanding the connection among theory, the designed interventions and practice. Similarly, studies on specific interventions may contribute to learning theories (Design-Based Research Collective, 2003). In other words, DBR is an iterative procedure of examination including a kind of intervention and which leads to the development of theories and practices with the potential of having an impact on classroom learning and teaching. Hence, it is highly likely that DBR will enable researchers to not only utilize the theory and relevant literature but also employ the evidenced findings of the study related to the teaching and learning setting in order to improve theories and practices (Barab & Squire, 2004). With this aspect, in educational settings, design-based studies have the potential to contribute to bridging and establishing a close connection between theory and real classroom practices (van den Akker et al., 2013). Thus, the present study, which aimed to develop an engineering design curriculum for PI in ECE by considering the need for engineering education opportunities for preschool children, overlapped with the aim of DBR as regards designing a useful and theory-oriented educational product and developing it in practice (Collins, Joseph, & Bielaczyc, 2004).

DBR is the research of context-based learning activity in a systematically designed learning environment (Design-Based Research Collective, 2003). Therefore, it utilizes theories and previous research findings and aims to contribute to the body of literature (Plomp, 2013). Similarly, investigation of a designed educational curriculum with the consideration of the relevant literature in engineering education in early childhood, and to thus contribute to the body of knowledge is one of the purposes of this study. Therefore, DBR enabled the researcher to design and develop an educational curriculum by considering the suggestions of previous studies on integration in a consistently designed teaching and learning procedure within a field and context, and to make contributions to the relevant literature.

In DBR, practitioners and researchers work collaboratively in order to create meaningful improvement in contexts of implementation including “classrooms, on-line communities or after-school programs” (Design-Based Research Collective, 2003, p. 6). On the other hand, teachers generally cannot find enough time or training opportunities to carry out a research study, or researchers do not have enough information about complicatedness of real learning settings in order to design an efficacious intervention (Anderson & Shattuck, 2012). Similarly, multiple stakeholders are essential elements of DBR (Collins, 1999), and in this study, the research group included preschool children, their teachers, and their parents as people who share the responsibility of children’s education. At that point, as essential design components of a learning setting from the viewpoints of the teacher, the researcher, and parents, DBR allowed the researcher to examine the characteristics of an early engineering education (EEE) environment and the essential elements of the learning process. In this way, DBR made possible to obtain a holistic understanding of those components in terms of theoretical and practical foundations.

By its nature, DBR aims to design and develop research-based solutions to complex educational practices or to develop or validate educational theories. Therefore, the research process in all DBR includes some systematic design steps (Design-Based Research Collective, 2003) which begin with the identification of a need or problem and end with the production of a solution (see Figure 11). Indeed, it includes an iterative cycle which includes some activities such as analysis, design, and development of a prototype, evaluation, and revision. This iteration process continues until the intended balance between the ideals and the realizations are reached (Plomp, 2013). Design-based practices are seldom perfectly designed and applied; hence, there is always room for development in the design and the following evaluation (Anderson & Shattuck, 2012). Accordingly, it was important to undertake many iterations in this study, which aimed to design a new curriculum, to develop this curriculum by means of the data collected during different implementations and to explore the barriers and facilitators of this curriculum. The researcher and the teachers who were the members of the research team of this study engaged in DBR, and thus experienced the iterative design process, which was also experienced by the children and their parents during EDP. Therefore, using DBR enabled the teacher and the researcher to better understand the phases of EDP, and, in the light of their design experiences, to take more effective steps when refining the intervention.

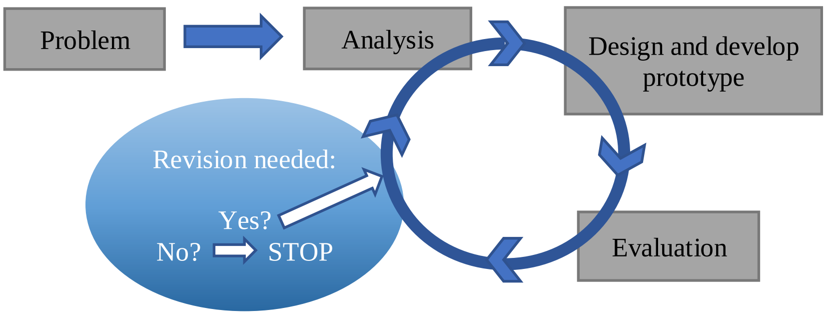

Figure 11 Iterative cycles in DBR (Plomp, 2013, p. 17).

3.1.2 Design-based Research from the Curriculum Perspective

Educational researchers handle DBR from various perspectives, namely the learning design perspective (Gravemeijer & Cobb, 2013), the technology perspective (Reeves, 2006), and the curricular perspective (McKenney et al., 2006). The current study is a DBR conducted from a curriculum perspective because it aims to reach an effective and practical engineering design curriculum, related design principles, and professional development of all the participants.

DBR in the curricular domain result in three main outputs. Design research conducted in the curriculum domain lead to generating knowledge, as well as to contributing to the society by producing educational programs and curricular products which are valuable for schools and educational communities. Besides, both processes and procedures carried out in design research contributes to participants' professional development (McKenney et al., 2006) (see Figure 12). In the present study, the problem of lacking an effective and practical engineering design curriculum grounded on PI and STEM for preschool children were considered and explored. In line with this problem, EDCPI was provided by constructing design principles (Plomp, 2013) identified and addressed in line with theory and practice (Reeves, 2006). Hence, the curricular product of the current study is the EDCPI as an intervention to meet the need for such a curriculum. Besides, the design and development of the EDCPI as an effective and useful intervention was based on the collaborative work of a practitioner and the researcher (Plomp, 2013). Therefore, the professional development of the stakeholders was the indirect output of the research process. Lastly, the detailed knowledge concerning the main characteristics of the EDCPI and learning environments where such a curriculum is implemented represent the design principles of this study (McKenney et al., 2006). Indeed, this study is intended to guide specifically the structuring of engineering education environments and activities for preschool children, realized with the involvement of parents (Collins, Joseph, & Bielaczyc, 2004). In line with this aim, eight design principles were formulated, put into practice, developed and modified by means of the expert reviews and iterative prototypes (van den Akker, 2013). Hence, the final generalizable design principles were established to guide future implementers of the curriculum.

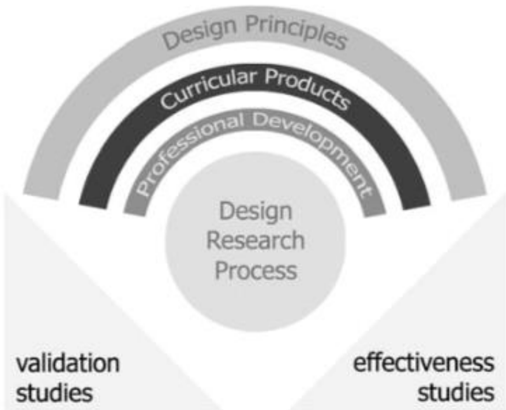

Figure 12 Main outputs of curriculum design research, supported by validity and effectiveness studies (McKenney et al., 2006, p. 75).

A curriculum design research study, although not highly universal, creates room of varying degrees for participatory design in the design and implementation of the curriculum. Participatory design is based on the contribution of the end users of the curriculum to the design process. Thus, the insights of the researchers are augmented by the participants, such as students, teachers, administrators and external experts (McKenney et al., 2006). Similarly, the present study was a participatory design research study, in which participants (teachers, parents, children) and field experts were consulted throughout the process from developing the EDCPI to evaluating its effectiveness.

In DBR, developing a high-quality intervention is the main aim of the design researchers. More specifically, educational design researchers strive to design high-quality solutions that can address the complex problems encountered in the educational practice under study (Nieveen & Folmer, 2013). Developing a high-quality curriculum is the main aim of this educational design research. Hence, both the formative evaluation and the following four main quality criteria shed light on the design process of the current study (Plomp, 2013).

- *Relevance* (content validity) refers to the degree to which the intended curriculum is perceived as a relevant development for practice from the perspectives of practitioners, policymakers, and researchers.
- *Consistency* (construct validity) refers to the extent to which the curriculum is designed on the ground of the state-of-art knowledge and the extent to which different components of the intervention are consistent with each other.
- *Practicality* refers to the extent by which both users and experts regard the intervention as explicit, usable, and low cost under normal conditions (van den Akker, 2010).
- *Effectiveness* indicates to what extent the intended outcomes are reached. Although the effectiveness is the end goal of the curriculum design researcher, the other three quality criteria may serve as a guide for the researcher in optimizing the design and development process (Plomp, 2013).

When the design research study is completed, the intervention should be sufficient in terms of all these criteria (Nieveen & Folmer, 2013). At that point, formative evaluation takes a central place since it enables the researcher to optimize the intervention (van den Akker, 2010) and to improve the quality of the prototypes (rather than to prove it) (McKenney et al., 2006). Formative evaluation can be defined in the scope of DBR as "a systematically performed activity (including research design, data collection, data analysis, reporting) aiming at quality improvement of a prototypical intervention and its accompanying design principles" (Nieveen, 2010, p. 93). It focuses on both determining imperfections of the prototypes of the intervention and especially generating suggestions about the ways of improving those weak aspects (van den Akker, 2013). In this way, it provides the researcher with information on what to do during the next step in the iterative design cycle and contributes significantly to the curriculum being developed by increasing its quality (van den Akker, 2010). As McKenney et al. (2006) emphasize, evaluation activities may be performed by the participation of the educational designer herself/himself, experts, teachers, parents, students, and other related stakeholders. Besides, during formative evaluation, some approaches can be utilized, including developing screening, micro evaluation, classroom tryouts and/or expert review (see Table 8). Nieveen and Folmer (2013) briefly explain these approaches as follows:

- *Screening*: Design is controlled by the members of the research team and data can be collected through a checklist for the necessary features of the intervention.

- *Focus group (also known as expert appraisal)*: This approach involves reacting to the prototype of an intervention by an expert group (e.g. subject matter experts, teachers, or design experts). Data can be collected through interviews.
- *Walkthrough*: The research team and a representative group of the target sample carry out a prototype (like in a theater play). Data can be collected through checklists, interview with the participants, and observation (p. 162).
- *Micro-evaluation*: A target user group (e.g. teachers and/or students) consisting of a small number of participants utilize intervention outside its typical user setting. Data can be collected by means of interviews, observation, questionnaires, and assessment tools (e.g. performance tests, learner reports, or portfolio).
- *Try-out (field test)*: The product is used in practice by the target group. In the evaluation, if the focus is the applicability of the intervention, observation, interview, logbooks, and questionnaire can be used. If the focus of the evaluation is the effectiveness of the intervention, students' performance can be assessed by means of tests, student reports and/or portfolios.

However, as Dick, Carey, and Carey (2015) emphasized, a distinction should be made between the target population and the try-out learners. Indeed, the target population represents the widest potential range of users (e.g. preschool children, seven graders, teachers, and adults). On the other hand, try-out learners are the available learners to the researcher as the intervention is being developed, and they are assumed as a sample of the target population. Therefore, in the current study, while preparing a curriculum addressing the preschool children and their parents, the participants of the micro-evaluation and try-out study served as a representative sample of the target users in order to design the EDCPI and reveal how well the curriculum worked after some developments.

As emphasized by Nieveen and Folmer (2013), the design and approaches used in each stage of research and each prototype of the intervention in formative assessment should be chosen by the design researcher in line with the objectives of the study. Table 7 contains information regarding for which quality criteria and at which stage of the DBR these methods can be employed.

In the present study, the screening of the design was conducted by the members of the thesis monitoring committee, called the "*design support team/group*". This team provided support to the study with their valuable suggestions throughout the design and the development process of the EDCPI, and decisions related to the design were made within this team. In fact, the researcher shared her revision and modification ideas on the prototypes with the design support team and revised the content by consulting them for their suggestions. The team consisted of three experts, one of whom held a PhD degree in the field of science education, and the other two held a PhD degree in the field of early childhood education. As explained in the following sections, the design support team held meetings five times throughout the research process and evaluated the developments in the study.

Table 8

Formative evaluation methods and relevant quality criteria (Nieveen & Folmer, 2013, p. 162)

Quality criteria		***Design stage***			
		Design proposal	*Global design*	*Partly detailed intervention/ product*	*Completed intervention/ product*
Relevance		• Screening • Focus group	• Screening • Focus group	• Screening • Focus group	• Screening • Focus group
Consistency		• Screening • Focus group	• Screening • Focus group	• Screening • Focus group	• Screening • Focus group
Practicality	*expected*	• Screening • Focus group	• Screening • Focus group	• Focus group • Walkthrough	• Focus group • Walkthrough
	actual			• Micro-evaluation	• Micro-evaluation • Try-out
Effectiveness	*expected*	• Screening • Focus group	• Screening • Focus group	• Focus group	• Focus group
	actual			• Micro-evaluation	• Micro-evaluation • Try-out

Note: The gray color indicates that the focus shifts from relevancy and consistency to practicality and effectiveness, and that more appropriate evaluation strategies are involved.

3.2 Phases of the Study

As aforementioned, the names of the phases used by researchers show variation, but design-based studies generally consist of three main phases (Plomp, 2013). In the *preliminary research phase*, needs and context analyses are conducted, the existing literature is reviewed, and a conceptual or theoretical framework for the study is developed by the researcher. In the second phase, the *prototyping phase*, numerous iterations of the intervention are done (Kennedy-Clark, 2015). The iterations are key parts of design studies (Reeves, 2006), and each iteration represents a micro phase for the design research. Indeed, curriculum design research aims to reach consecutive prototypes rather than to evaluate and implement a completed intervention. In each of the prototypes, the design research aims to bring an intervention become one step closer to the innovative needs (van den Akker, 2010). Each of these micro phases is an independent work that can focus on a specific aspect of the research by utilizing formative assessment, which is the most crucial research activity at the end of each phase (Kennedy-Clark, 2015). In the third and last phase of design research, which is the *assessment phase*, researchers focus on undertaking a summative assessment to determine if the intervention or the proposed solution meets the pre-established specifications. This phase is called semi-summative, since it usually results in suggestions for the improvement of the intervention (Plomp, 2013).

In the present study, these three phases were followed during the curriculum design and development process. First, within the scope of the preliminary research phase, the relevant literature was reviewed, and a needs and context analysis were carried out to gain background information to determine initial design principles for the EDCPI (McKenney, 2001; Thijs & Akker, 2009). These activities enabled the researcher to explore the setting in which the EDCPI would be implemented and to outline the scope of the EDCPI. Indeed, by conducting a literature review, it was focused on current practical works, frameworks, and standards in EEE (Mafumiko, 2006). In this way, the content of EEE, key components for learning in engineering and STEM, and characteristics of a preschool engineering education curriculum were identified. In addition to this review of the literature, a context analysis was performed by conducting an informal interview with the participant preschool teachers. Thereby, the user context, the teachers' needs and current implementations, the extent of the teachers' and parents' willingness to change, the type and frequency of the PI activities in the participant teachers' classrooms, and the extent of available agents for improvement, such as time, staff, and resources were explored (Thijs & Akker, 2009). In other words, context analysis provided a refined image of the current status of engineering education and PI in early childhood in preschool classrooms. After these preliminary acts, the preliminary version of the EDCPI was designed in order to identify curricular goals and pedagogy (Clements & Sarama, 2007).

Secondly, in the prototyping phase, the prototypes of the intervention were iteratively developed and revised by using formative evaluation. Through all the phases of the formative evaluation, the prototypes of the EDCPI and the design principles were revised and reshaped. During this process, the research methodologies presented by Nieveen and Folmer (2013) guided the research in designing the prototyping process and the followed steps. Besides, some of the formative evaluation methods were chosen according to the aim of the study and the process of formative evaluation was planned accordingly (see Figure 13).

The first iteration of the formative evaluation phase was planned to include both screening and focus group methods and was named as expert appraisal. Initially, the screening method was carried out. Three experts from the design support team from the fields of science and early childhood education (ECE) checked the design and provided the researcher with information on the identification of the characteristics of the EDCPI.

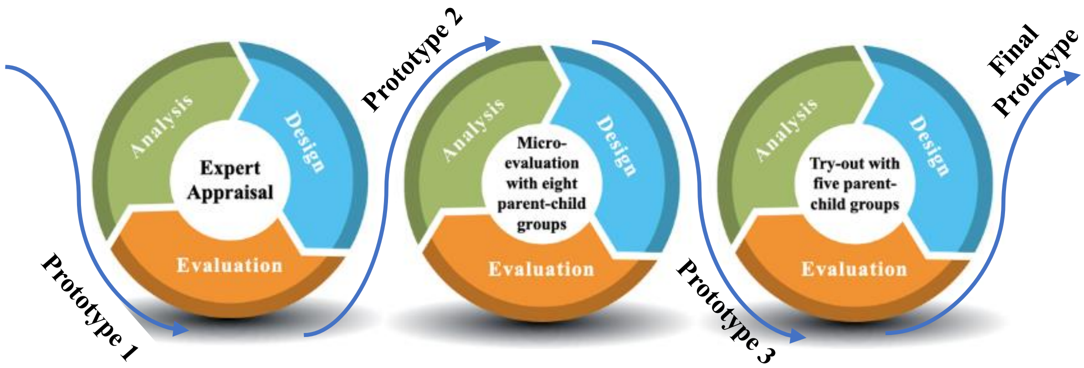

Figure 13 Iterations of the formative evaluation process followed in the current study.

Secondly, the focus group method was used, and six experts from the fields of early childhood, science, mathematics, and engineering education were consulted in terms of the consistency and relevancy of the EDCPI. Each field expert reviewing and evaluating the second prototype of the EDCPI provided valuable information with respect to her/his field about the irrelevant and inconsistent properties of the EDCPI, thus contributing to its improvement. The second iteration was planned as a micro-evaluation study. In this context, a preschool teacher, eight children in this teachers' classroom, and the parents of these children participated in the study. In this regard, the second prototype of the intervention was performed with a sample from the target user group, but outside the EDCPI's typical user learning environment. At this point, the main aim was to investigate the practicality of the curriculum and the expected contributions of the EDCPI to the participants (effectiveness). Lastly, the third iteration was planned as a try-out study. The third prototype of the EDCPI was implemented with a small number of the target user group in the typical user setting. The try-out was carried out in a real preschool classroom environment with two preschool teachers, five children in these teachers' classrooms, and the parents of these children (see Figure 14). The focus was again to examine the effectiveness and practicality of the EDCPI.

Finally, in the summative evaluation phase (Mafumiko, 2006; Wang et al., 2014), the focus was to evaluate the effectiveness of the EDCPI. In other words, determining to what extent implementation of the EDCPI brought about its intended objectives was the aim in the last phase (Thijs & van den Akker, 2009). On the other hand, in the present study, the actual practicality or effectiveness of the EDCPI could not be examined. After the try-out was completed, a final prototype of EDCPI emerged. This final prototype was not subjected to a final field test with the entire target audience or a sample of it. It was formatively evaluated by means of expert appraisal. Since the actual efficiency and practicality require further evaluation and field testing, in this study, conclusions regarding only the expected practicality and effectiveness (van den Akker, 2010) can be drawn.

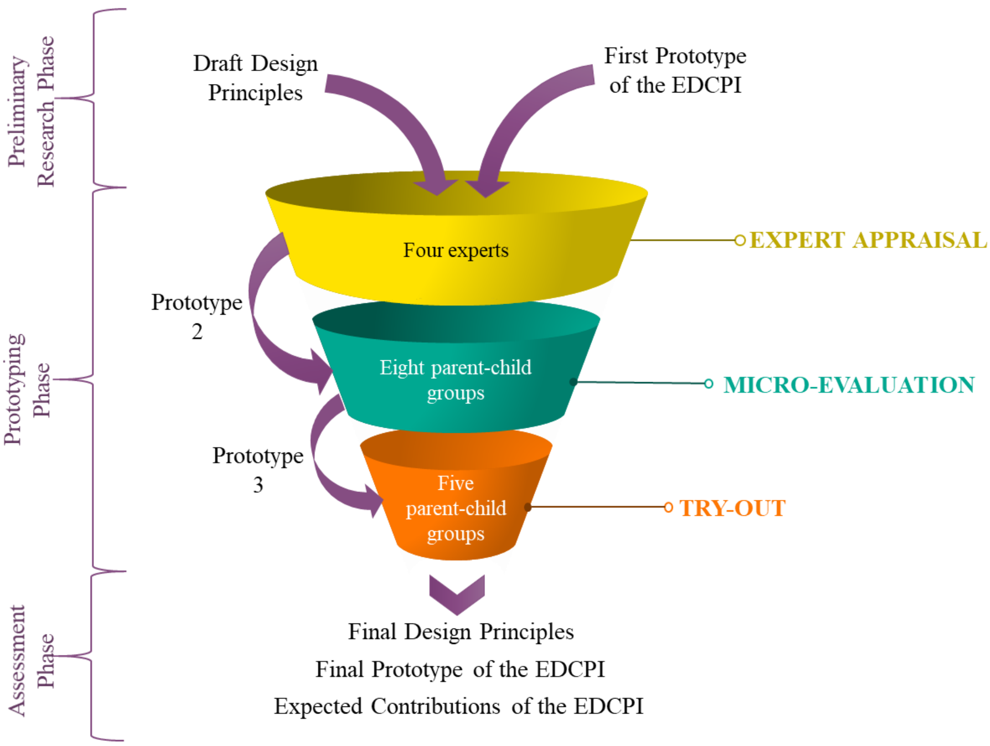

Figure 14 Phases of the current DBR.

3.2.1 Phase I: Preliminary Research Phase

The preliminary phase of the current study was based on the design of the curriculum. At this point, the curricular spider-web model of the van den Akker (2004) guided the researcher to design the EDCPI (see Figure 14). Firstly, the rationale of such a curriculum which connected all the curricular components was determined. Analyzing the current setting and formulating the aims for the recommended innovation is generally the starting point of a curriculum development process and provides a rationale for the curriculum. Therefore, preliminary research, which is the first phase in DBR, includes some activities such as analysis of the problem, context, needs, and knowledge base (Thijs & van den Akker, 2009). All these activities enable the researcher to establish a theoretical and conceptual framework of the study (Plomp, 2013). In addition, preliminary research activities enable the researcher to develop initial design guidelines that will be developed and tested to be transformed into a usable product throughout the study (Thijs & van den Akker, 2009).

In respect of preliminary research, in the current study, a need and context analysis were performed as the first step (see Table 8). As McKenney (2001) states, a detailed literature review and site visits are some of the ways of conducting needs and context analysis. In the current study, firstly, some preliminary research conducted by the researcher and her colleagues independent from the current study shed light on the researcher to reveal the needs in the STEM-related literature and practice in ECE. After the need for an instructional resource which might guide the preschool teachers to integrate STEM into their classrooms was identified, a detailed literature review was conducted. The needs and context enabled the researcher to determine the necessity of such a curriculum and the need for parents in the STEM education process of their children. The following subsection presents the details and findings of these analyses.

- *Needs and Context Analysis*

As abovementioned, the researcher and her colleagues conducted some STEM-focused studies. Although these studies were independent of the current study, they made some contributions to the researcher in the matter of determining the necessity for such a curriculum. First, the researcher conducted a study with another researcher to explore the current status of STEM in the field of ECE (Ata-Aktürk & Demircan, 2017a). In this regard, a detailed literature review was conducted by the researchers related to the studies focusing on STEM and arts-integrated STEM (STEAM) education in ECE and 22 research obtained from this detailed literature review was analyzed. The findings of the study revealed that although more studies have been conducted over the last decade on these two subjects, STEM and STEAM were the subjects of a limited number of studies in ECE literature. The findings of the study also showed that most of these studies were conducted with only preschool children, or only with preschool teachers. However, findings of the study revealed that a handful of studies included both preschool teachers and preschool children and a limited number of studies was conducted on STEM education in Turkey. In another study, the researcher and colleagues explored the current Turkish ECE curriculum in terms of STEM. Findings indicated that, although the curriculum (MoNE, 2013) was appropriate for the integration of STEM, it needed sample engineering activities which integrated science, math, and technology (Ata-Aktürk et al., 2017).

After the abovementioned review study, another study was conducted to investigate preschool teachers' views about STEM and arts integration into the STEM (Ata-Aktürk &

Demircan, 2017b). To that end, interviews were conducted with seven preschool teachers working in two different public schools. Findings revealed that most of the preschool teachers were handled STEM disciplines as independent from each other in their classroom implementations and that the reason for this was preschool teachers' lack of knowledge in STEM. Participant teachers of the study stated that their undergraduate education did not provide them with sufficient knowledge and skills to prepare and implement integrated activities. The findings also indicated that teachers need to practical studies which would be conducted by collaborating with educators in universities to obtain the required knowledge and skills on up-to-date approaches such as STEM and STEAM and integrate these approaches into their curriculum.

In summary, the studies conducted prior to the present study provided the researcher with information about the current status of STEM in the early childhood education literature and the appropriateness of the current ECE curriculum for STEM integration. These studies also signified that preschool teachers considered themselves inadequate regarding the STEM and they needed the collaboration with the experts about how to integrate STEM into preschool classrooms. In other words, these studies had drawn the researcher's attention to preschool teachers' need for STEM-based teaching resources and their need for the guidance of experts to bring STEM into the classroom. By considering this need, a detailed literature review was conducted in the preliminary research phase of the current study. This review indicated the researcher that engineering contains other STEM disciplines and serves as a catalyst for the integration of them (Moore, Tank, Glancy, & Kersten, 2013). In fact, the literature indicated that a developmentally appropriate engineering design curriculum might provide preschool children learning opportunities in STEM (Bagiati, 2011; Lippard et al., 2018; Torres-Crespo et al., 2014) and that it might provide preschool teachers with a research-based curriculum to integrate STEM into their classrooms (Bagiati & Evangelou, 2015; Davis et al., 2017). In addition to the role of the engineering in STEM education, the literature review of the researcher on pre-college engineering education indicated that parents play an important role in their children’s learnings in engineering and STEM and children's interest to these fields (Dorie & Cardella, 2014; McClure et al., 2017; Smetana et al., 2012; Yun et al., 2010). Therefore, in the current study, a decision was made to design and develop an exemplary STEM-based early engineering curriculum involving the parents into their preschool children’s education process and based on empirical evidence. Such a curriculum might serve as a guide for preschool teachers by providing them with a culturally and developmentally appropriate instructional resource that could enable them to integrate STEM into their classrooms and get support from the parents in the learning process. Reviewing the relevant

Table 9

Phases and procedures of the study, and purpose and timeline of these phases

Phases of the Study	***The Procedures Followed***	***Time Schedule***	***Purpose***	***Criteria***
Preliminary research phase	• Analyzing the context • Reviewing the literature • Screening with the design support team • Reviewing the literature • Designing the EDCPI content • Planning the EDCPI implementation process	• December 2016-April 2017 • December 2016-April 2017 • May 2017 • June - September 2017 • June - September 2017 • September - November 2017	To reveal the factors that should be taken into consideration while designing and developing EDCPI	Relevance Consistency
Prototyping Phase • *Expert Appraisal*	• Screening with the design support team • Continuing the analysis • Receiving expert appraisal • Revising the EDCPI content • Revising the data collection tools • Screening with the design support team	• December 2017 • December 2017 - March 2018 • January 2017 • January 2017 - February 2018 • January 2017 - February 2018 • March 2018	To develop the EDCPI's draft design based on the perspective of the field experts	Relevance Consistency
Prototyping Phase • *Micro-Evaluation*	• Conducting the micro-evaluation study with a preschool teacher, eight children in her classrooms, and the parents of these children • Conducting the analysis • Screening with the design support team • Revising the EDCPI content • Revising the data collection tools	• March - April 2018 • March - June 2018 • May 2018 • June - August 2018 • June - August 2018	To improve the EDCPI from the user's perspective and to reveal its expected practicality for the target users	Practicality Effectiveness
Prototyping Phase • *Try-out*	• Conducting the try-out with two preschool teachers, five children in their classrooms, and the parents of these children. • Continuing the analysis • Screening with the design support team • Revising the EDCPI content • Revising the observation form	• October - November 2018 • October - December 2018 • December 2018 • December 2018 - February 2019 • December 2018 - February 2019	To improve the EDCPI from the user's perspective and to reveal its expected practicality and effectiveness.	Practicality Effectiveness
Assessment Phase (Semi-summative evaluation)	• Performing the final analysis • Receiving expert appraisal • Conducting the final evaluation	• March - April 2019 • March - April 2019 • April-May 2019	To reveal the possible contributions of the EDCPI to the target users.	Practicality Effectiveness

literature also provided the researcher with information about existing practices in early engineering education practices and practices focused on involvement of the parents into engineering education process (Bagiati, 2011; Bagiati & Evangelou, 2015; Cunningham et al., 2018; English, 2018; Pantoya et al., 2015; Sullivan et al., 2015; Van-Meeteren & Zan, 2010). In fact, the literature review enabled the researcher to analyze existing curriculum examples developed for similar purposes and existing case studies to understand and identify the needs and problems of the intended users of the curriculum (van den Akker, 2013). In this context, the review of the literature clarified the potential benefits of EDCPI that could contribute to preschool children's learning and could support EEE by means of PI.

The needs and context analysis activities carried out in the preliminary phase of the present study also provided evidence for relevance and consistency, which are two of the quality criteria. In fact, these formal activities and informal interviews with preschool teachers indicated that there was a need for a STEM-based engineering design curriculum addressing preschool children, their parents, and preschool teachers.

The research proposal, which included the design and development of such a curriculum, was screened in collaboration with the experts in the design support team. The experts suggested that the roles of the parents, children, and the teacher should be clearly defined in such a curriculum and that both teachers and parents should be provided with training before the implementation. Thus, the parent and teacher training phase were included in the planning of the intervention. All this information obtained at the initial stage of the present research design study provided the researcher with the identification of the draft design principles, which guided the design and provided a detailed plan for the intervention (Plomp, 2013). Eight design principles were constructed in total within the context of the first phase. These are summarized in the following section.

3.2.1.1 Draft Design Principles Underlying EDCPI

In line with the context analysis and literature review activities carried out in the first phase of this DBR, some draft design principles were constructed. In this process, in addition to the early engineering literature (e.g. Bagiati, 2011; Cunningham & Lachapelle, 2016), the DAP and Turkish ECE curriculum (MoNE, 2013) were used as a framework for determining the basic characteristics of EDCPI. These following design principles, which guided the design of the EDCPI content, and which may serve as a guide for similar studies and development efforts (Amiel & Reeves, 2008), represent these important characteristics of the EDCPI.

3.2.1.1.1 Developmentally Appropriatenss

According to Coople and Bredekamp (2009), researchers should consider some points when they plan a developmentally appropriate curriculum to achieve the essential goals. These points also guided the development process of EDCPI.

- *Clearly identified and articulated learning objectives*

EDCPI should have clearly identified and articulated the learning objectives. The educational objectives that are important for the learning and development of preschool children in the context of EDCPI should be determined in accordance with the relevant literature. These objectives should also be clearly defined in the planning templates of the relevant activities to ensure that they are understandable and negotiable by the relevant stakeholders and that they guide teachers during the implementation of EDCPI (Copple & Bredekamp, 2009).

- *Coherency with classroom experiences and the real-world*

EDCPI should ensure the active involvement of children in the learning process. Preschool teachers should benefit from the curriculum framework to ensure that their plan addresses important learning objectives and to strengthen the consistency of in-class experiences for preschoolers (Copple & Bredekamp, 2008). In addition to the consistency of classroom experiences, consistency should also be provided with real-world practices. EDCPI should include learning experiences which are familiar to children and relevant to both their school life and their daily life outside of the school environment (Dubosarsky et al., 2018). Indeed, EDCPI learning activities should be organized in relation to real-life situations that show children how and where engineering knowledge and tasks can be implemented. To this end, EDCPI should motivate children and improve their awareness of the importance of engineering for the world by using stories and by demonstrating to them how engineers help living beings and contribute to the development of the society. In addition, examples of engineers from different demographic characteristics, such as gender, race and ethnicity, and different interests and different abilities/disabilities, should be presented to children by means of children's picture books, stories, and engineers from their real life (Cunningham & Lachapelle, 2016).

- *Appropriateness with developmental needs, interests, and characteristics*

As a developmentally appropriate curriculum, EDCPI should be based on the knowledge of children's development and learning, the knowledge of each child's strengths, needs and interests, and the knowledge of the cultural and social environment where each child lives (Copple & Bredekamp, 2009). In this regard, all the activities and related learning objectives in the EDCPI should be determined in the light of what is known regarding developmental and educational characteristics, needs and interests of the studied age group, and their cultural and family contexts. Developmental levels and characteristics of preschool children should be taken into consideration so that it can guide the researcher to create an emergent engineering design curriculum. At that point, all the curricular materials and activities within EDCPI should be prepared by cooperating with the teachers of the studied preschool classrooms as they are one of the sources who know each child's characteristics, needs, the ways of learning and family environments in her/his classroom.

Lastly, parents may differ from each other in terms of their socioeconomic status, background and attitudes toward EEE, their educational level, or some cultural and social characteristics. Since the EDCPI addresses preschool children by benefiting from their parents' involvement in engineering education, these differences should also be considered. In order for the curriculum to be inclusive not only for children but also for parents, prior to the implementation of the activities, all parents should be included in a one-day training to ensure that they have basic knowledge of engineering education in early childhood. In addition, in all activities taking place within the scope of the EDCPI, effort should be made to choose materials (most of them are open-ended and readily available materials) that would be accessible to parents of every socio-economic status. All the books and stories used as a means at the beginning of each activity should be selected by considering the cultural and social differences among parents (Cunnigham & Lachapelle, 2016).

In a preschool classroom, some children may be underrepresented in STEM-related fields or some of them may be underserved (Cunnigham & Lachapelle, 2016). Therefore, an inclusive curriculum should be adaptable to address the target preschool children's learning needs and characteristics. Indeed, as an exemplary engineering design curriculum, EDCPI should enable teachers to be flexible in designing and practising curricular experiences in preschool classrooms (Copple & Bredekamp, 2009). In other words, sample learning activities within the EDCPI should be adaptable and individualizable to the changing learning characteristics of children, learning environments, and parents. Moreover, the EDCPI should guide preschool teachers to prepare new engineering activities for the children in their classroom through learning objectives and indicators identified. Similarly, all learning activities in the EDCPI should be simple activities that parents can adapt to their children's home environment and require no other equipment than the materials usually found in homes.

- *Connectedness with the existing curriculum*

Providing children with meaningful connections between the learning experiences is a priority for a preschool teacher in a developmentally appropriate curriculum. Establishing meaningful connections between new information and concepts, skills, language, and information they learned in advance is the best way to learn for preschool children (Copple & Bredekamp, 2009). The context analysis conducted at preliminary research revealed that the crosscutting concepts, disciplinary core ideas, and main practices utilized in STEM approach were parallel with the educational goals and concepts that preschool children expected to gain in the current Turkish ECE curriculum (Ata-Aktürk et al., 2017). For this reason, the engineering activities in EDCPI should focus on these concepts and practices that are included in the science and engineering education in order to ensure compatibility with the existing ECE curriculum. In addition to learning objectives related to engineering and STEM, EDCPI should be prepared in parallel with the existing learning objectives and indicators, and learning concepts in the current Turkish ECE curriculum (MoNE, 2013). Lastly, the connection with the existing curriculum should be provided by discussing and planning with participant preschool teachers in order to ensure the connectedness with prior learnings and daily-life experiences of children. For example, during a discussion of a learning activity, a preschool teacher may suggest adding to the learning process some points related to a unit that they are covering during that week in accordance to the school curricula.

3.2.1.1.2 Balance in terms of Learning Objectives

EDCPI is a curriculum that aims to encourage preschool children to learn about engineering and STEM. In such a curriculum, it should be ensured that the objectives and indicators are balanced in the areas of learning and development (MoNE, 2013). In this context, in EDCPI learning activities, four main dimensions (knowledge, skills, dispositions, and feelings) (Katz, 1999) and various development areas (e.g. social, cognitive, physical) should be balanced. This balance should also be valid for five different ways of thinking addressed within the dispositions in this study. Although most of the activities in this curriculum could be utilized to support children in more than one way of thinking, the curriculum includes five sample activities, each of which focuses on a thinking skill.

3.2.1.1.3 Learning by Discovery

Learning by discovery is based on the active participation of a child in his/her education process, and transfer of learning into other fields and circumstances (MoNE, 2013). For preschool children, access to materials, manipulation of these materials in their own ways, transformation and fragmentation of these materials, and having enough time to do all of them is a prerequisite for the discovery process (Hohmann & Weikart, 1995). EDCPI should encourage preschool children to learn by exploring and make them gain experience with both open-ended daily items (e.g. rubber band, plastic bottle, aluminum foil, paper towel, cardboard, fabric, plastic container, button, pulley, marble) and with materials from the nature (e.g. leaf, pine cone, tree branches, stones). In this way, children should find the opportunity to explore these materials' different characteristics such as surface, size, and the material used in their construction. Moreover, EDCPI should support learning through exploration by encouraging children to pose questions and discover possible answers through EDP.

3.2.1.1.4 Learning by Designing

Constructionism, which is one of the frameworks underlying EDCPI, advocates that children learn more effectively if they are provided with a chance to design, create and engage with projects which are individually and epistemologically meaningful for them (Bers, 2008). Starting from this point of view, in EDCPI, all the activities should be planned to engage children in EDP under the guidance of their parents. EDP is based on defining human problems, producing solutions to solve them by using creativity and the knowledge of different disciplines, such as mathematics and science, testing the produced solution and improving it in the light of test results (Stone-MacDonald et al., 2015).

The EDP experienced in this curriculum should enable preschool children to recognize a problem, to think about possible solutions, to make a plan about their solutions, and to test and improve their solutions by engaging in EDP under the guidance of their parents. In this context, in each activity in EDCPI, a different problem (engineering challenge) should be presented to the children to produce design solutions to this problem through engineering. The presented problems to the children should be open-ended challenges which reinforce children's creativity and lets them generate multifarious solution ideas (Cunningham & Higgins, 2014).

3.2.1.1.5 Providing Preschool Children with Experience in STEM

EDCPI should be a STEM-based curriculum and provide children with the opportunities to use and develop their knowledge and skills related to STEM concepts by means of engineering design activities. Indeed, children should experience some STEM-related concepts by engaging in engineering design activities within the curriculum. Furthermore, children should produce novel technologies to the problems presented to them as well as taking the advantage of the technologies produced by others (e.g. digital cameras and craft papers to keep records of their design solutions) (Stone-MacDonald et al., 2015).

3.2.1.1.6 Importance of Experiences based on Creativity and Usage of Daily-life Materials

As Cunningham and Lachapelle (2016) emphasized, when researchers develop an engineering curriculum, they should ensure that the engineering education is appealing and thought-provoking for all children. Indeed, in an effective early childhood curriculum, children are provided with first-hand and meaningful experiences which stimulate them intellectually and creatively, make way for exploration and inquiry, and promote children's active involvement. To achieve this, a wide array of materials and challenges that children might be interested in should be included in the education process (Copple & Bredekamp, 2009). By considering this, in EDCPI, children and their parents should be provided with different engineering design challenges, and all the processes should be established on their creative potential. All activities in the curriculum should be designed to allow children to express themselves and their creativity in a unique way. Moreover, in EDCPI, all activities should be activities which allow children to use open-ended and daily-life materials in different ways. Therefore, a wide variety of open-ended materials should be provided to them throughout the implementation process of the activities. By experiencing these materials, children are aimed to view these materials from a different perspective, and to explore different usages of these materials.

3.2.1.1.7 Learning Process Supported by Parental Involvement

As a child grows up, both the school and the family environment are actively involved in his/her life. EDCPI was prepared with the idea that common objectives and approaches need to be adopted and exhibited in the school and family environment of the child (OBADER, 2013). In EDCPI, the involvement of parents or other family members into the child's education process is referred to as PI. PI takes place in or outside the school and includes a two-way communication between the school and family to improve children's learning (Morrison, Storey, & Zhang, 2011). According to EDCPI, as one of the stakeholders of preschool children's education, parents need to be involved in their children's education in different social settings, such as the school, home and community, which ensures the continuity and permanence of learning at school (Hindman et al., 2012). For this reason, EDCPI defends that parents are important agents in their children's learning in engineering, and parental participation is the key to young children's mastery of engineering interest and mastery of engineering skills (Bagiati et al., 2011). According to EDCPI, parents can contribute to their children's early engineering thinking and experiences by means of their interactions with their children, and by providing their children with opportunities to experience engineering at home (Dorie & Cardella, 2014). They may even be a step forward for engineering education to expose preschool children to artifacts at home, to enable children to interact with these artifacts, and to talk about the working system of some technologies with the child (Bagiati et al., 2011). In addition, EDCPI maintains that parents can support engineering and STEM learning by guiding their children in designing technologies as a solution to various problems and to guide them in acquiring various knowledge and skills in this process (Smetana et al., 2012). Therefore, EDCPI grounds on PI in preschool children’s engineering education. On the other hand, as Copple and Bredekamp (2009) pointed out, it would not be developmentally appropriate to limit PI only to planned activities (although they are valuable) or to develop a relationship with parents based on a strong "parental education" tendency. To achieve curricular goals, parents and practitioners should respect each other, collaborate and share the responsibility with each other, and negotiate on the conflicts. In EDCPI, family members are welcomed in the education environment for PI, and parents are involved in decisions about the program applied in their children’s engineering education. Similarly, teachers and the researcher involve parents into the education process before and throughout the implementation process as a source of knowledge related to the child and collaborate with them in the planning of the education process for children (Copple & Bredekamp, 2009). In fact, in EDCPI, parents should be regarded as partners in their children’s engineering education process. In this regard, in EDCPI which offers parents the opportunity to experience involvement in their children's learning processes, the learning process should be reformed in the light of parents' and teachers’ evaluations and suggestions in the development and implementation of the curriculum. For this purpose, parents should be asked to make an evaluation of the week and their children after the activity is carried out every week during the implementation period. When the implementation process is finished, interviews are carried out with parents to evaluate both the curriculum and its implementation process. EDCPI should be revised after these evaluations are made by parents, who are one of the target users of the curriculum.

In addition to all above-mentioned issues, some ethical principles mentioned in the OBADER (2013) should be considered when designing and implementing any content based on PI. In line with these ethical principles, the EDCPI should be prepared by considering parents from different cultural, ethnic, and socio-cultural backgrounds. Hence, it should be especially paid attention that both parental training and the activity implementation process do not include any cultural, ethnic, or socio-cultural bias. In fact, such a bias may create a barrier to PI (Hornby & Lafaele, 2011; Hornby & Blackwell, 2018). In addition, EDCPI should be based on volunteer participation of parents and their children. Only parents who signed the voluntary participation form should be included in the study with their children and all the participant parents should be informed that if they are uncomfortable, they can leave the study. The privacy policy should also be considered throughout the study. Parents should be asked not to take pictures with their mobile phones during the activities and not to share any photos regarding the activity process on social media. Parents should be informed that taking photographs during activities may distract both their children and other children and that any sharing on social media may disturb other parents and/or children. Besides, researchers and teachers should adopt the principle of confidentiality and the personal information of the participating children and parents should be kept completely confidential throughout the study. Parents and teachers should be informed that their personal information will not be shared anywhere and that the data obtained would be used only for academic purposes. In addition, the implementation of all curricular activities and the evaluation process should be based on the honest, detailed and fair study of both the teacher and the researcher. Most importantly, all the content of EDCPI should be prepared for making parents more aware of their importance to and effect on their children's education and development process.

3.2.1.1.8 Versatile Assessment Process

Assessment is a tool to track how children progress towards the desired goals of a curriculum (Copple & Bredekamp, 2009). EDCPI should be based on versatile assessment, which enables to support preschool children's learning and to improve the curriculum and its implementation process. All design challenges presented to children within EDCPI should be planned so that they are open to different solutions and answers rather than a single way to reach the answer or one correct answer. Indeed, both process and product should be important for EDCPI. Therefore, the design challenges in the context of EDCPI should be planned so that it is appropriate for assessment in terms of both the design process and product. Besides addressing the learning objectives of the curriculum, assessment should be formative in terms of the instruction process and children's learning and provide the teacher with summative information about each child's ability and growth (Purzer & Douglas, 2018).

In a successful design, the product should reflect the child's ideas and efforts. Parents are the guides of this learning process in which the child is at the center. Therefore, parents should be informed that a design process in which they produce and construct a solution idea on their own and in which the child is not an active participant in the learning process cannot be considered successful. Parents should also be given the information that, in EDCPI, the child's success is also related only to what s/he has learned in the process rather than only with the product the child has constructed. In fact, the success in EDCPI should be related to the fact that the child should be able to produce solutions by considering certain limitations to the problem presented to him/her, and that the solution s/he produces should be open to improvement even if it cannot solve the problem. Besides, in a successful design process, failure should be considered as a part of design challenges. Hence, by means of the process, the message that the failure of an engineer is a step that would carry on to future success should be conveyed to both children and their parents (Cunningham & Lachapelle, 2016).

EDCPI should also give importance to versatile and individual evaluation of each child. This evaluation should be made by looking at the difference between the starting point and the point reached at a particular point in time (by means of a set of data sources such as an interview and/or observation). Besides, evaluation of children should be carried out in EDCPI by means of the documentation technique that focuses on each child's developmental process as well as important learning objectives (Mcafee & Leong, 2012). For this reason, observation forms should be kept by the researcher and the teacher for each parent-child learning group, and photographs of sketches and designs and audio and video recordings should be included in the portfolios of each group.

In brief, these design principles formulated in the light of relevant literature and context analysis represent the initial characteristics of EDCPI. These eight draft principles of EDCPI were revised and developed throughout the cycles of prototyping by means of formative evaluations. The next step was to identify the instructional goals of the EDCPI, in other words, the knowledge and skills expected to be reached by the learners when they completed the learning process (Dick et al., 2015). Hence, the relevant literature was reviewed in the preliminary stage and the learning objectives of the EDCPI was also drafted. The following section describes how to create the draft version of EDCPI's learning objectives.

3.2.1.2 Design of the Aims and Objectives

After identifying the rationale underlying the EDCPI, the next step was to determine its aims and objectives (van den Akker, 2013). First of all, the goals of the curriculum were determined.

- Developing a EDCPI curriculum by being inspired from preschool children’s original and creative thinking, and from their way of solving everyday problems. Thus EDCPI, which allows preschool children to deal with engineering activities, aims to create new opportunities for them to identify design problems, to distinguish design possibilities in the world, and to think about how materials can be redesigned or about how to solve problems that require STEM knowledge and competence.

- Engaging parents in their children's engineering education through hands-on activities and thus building a bridge between the school and the family that targets the education of the child.
- Providing a developmentally appropriate resource to support preschool teachers who wanted to integrate engineering education into their classrooms and implement an effective way of PI.

These are the general curricular goals of EDCPI; however, EDCPI aims towards some specific learning objectives. In EDCPI , learning objectives are regarded as the results that are expected to be reached by learners throughout the education process. On the other hand, indicators created based on the learning objectives are the observable form of learning objectives and serve for the comprehension of learning objectives (MoNE, 2013). EDCPI includes various learning objectives for both preschool children and parents. These learning objectives and how they were determined are described in detail under the following sub-headings.

3.2.1.2.1 Design of the Learning Objectives for Parents

As aforementioned, by considering the importance of PI in education, EDCPI aims to actively involve parents of preschool children into their children’s engineering learning process by means of STEM-based engineering design activities. In this way, the knowledge and skills gained by parents about the ways of guiding preschool children’s engineering education during the EDCPI implementation process can support parents in terms of promoting their children’s engineering learning at home and in other environments outside the school.

Todays’ parents are trying to prepare their child for a world which is very different from the one that they grew up in. People in today's world of technology need much more advanced scientific and technological equipment than most of us did in the past. Even if children do not choose a career in science, technology, engineering and mathematics in their future life, they will need some knowledge in these areas to continue their daily lives. For this reason, children need the help and guidance of their parents in order to be ready for the future (U.S. Department of Education, 2005). However, parents may need knowledge about how they can guide their children's learning in these disciplines and what to expect from STEM learning in preschool institutions. They also need examples and knowledge regarding what a quality preschool STEM education looks like. Being an active part of their children’s education process provides parents with the knowledge and skills related to what early STEM learning looks like and how to contribute to their children’s STEM learning and interests outside of school (Early STEM

Matters, 2017). In addition, as Moomaw (2010) emphasized, parents can promote and facilitate their children's knowledge in STEM fields by recognizing STEM disciplines in children's play experiences. In view of this perspective, EDCPI believes that parents should have knowledge of what engineering is like, what a professional engineer does, the steps of the EDP, and what kind of behaviors his/her children exhibit similar to engineers during their daily lives or play experiences. As Smetana et al. (2012) stressed, it can be possible to provide parents with the opportunity to explore engineering with their children by means of first-hand engineering design activities, and to reveal their knowledge of engineering. Besides exploring engineering, parents should be able to help their children to recognize samples of engineering in everyday life, at school, and at home to guide their children's engineering learning. Parents should also learn how to maintain their children's curiosity about and interest in engineering out of the school setting (Dorie et al., 2014).

By taking the relevant literature into consideration, some learning objectives of EDCPI for parents were determined in the preliminary phase of the present study. These learning objectives, which were aimed to be reached by means of EDCPI, are presented in Table 10 below.

Table 10

Learning objectives of the EDCPI for parents

Learning Objectives	***Adapted from (Resource)***
• The parent understands what engineering profession is and what engineers do.	(Smetana et al., 2012)
• The parent gains an understanding of how engineering affects people's lives.	(Smetana et al., 2012)
• The parent is aware that engineering is a part of her/his preschool child's daily life.	(Davis et al., 2017)
• The parent gains an understanding of the importance and objectives of engineering education in early childhood.	(Early STEM Matters, 2017)
• The parent becomes aware that parents are valued in learning environments in terms of their children's engineering education.	(Dorie et al., 2014)
• The parent learns different ways of contributing her/his child's learning process in engineering.	(Smetana et al., 2012)
• The parent makes some changes in the home environment to support the child's engineering education.	(Stone-MacDonald et al., 2015)
• The parent has knowledge about the alternative ways of teaching and reinforcing their child's knowledge and skills in STEM-related concepts.	(Early STEM Matters, 2017)
• The parent feels comfortable while working with their children on projects concerning engineering.	(Hsu, Purzer, & Cardella, 2011)
• The parent monitors and is aware of the child's progress in engineering	(Stone-MacDonald et al., 2015)

3.2.1.2.2 Design of the Learning Objectives for Children

In EDCPI, learning objectives are regarded as the results (knowledge, skill, dispositions, and feelings) that are expected to be reached by children throughout the education process. On the other hand, indicators created based on learning objectives are the observable form of learning objectives and serve for the comprehension of learning objectives (MoNE, 2013). EDCPI aims to support children in four main dimensions of learning; knowledge, skills, dispoisitions, and feelings (Katz,1999). Therefore, the learning objectives of EDCPI in the current study were structured around these four main sub-dimensions. The following subheadings describe how these learning objectives were designed within each sub-dimension.

- *Learning Objectives in the Knowledge Dimension*

EDCPI aims to provide preschool children with some basic knowledge about engineers, engineering, and the importance of engineering in our life. It also aims to improve children's knowledge of engineering products and engineering examples existing in daily life. To this end, learning activities within the EDCPI proposes five knowledge related learning objectives to be reached by preschool children in the light of the relevant literature. In order to identify knowledge-related learning objectives, some curricula on early engineering learning in the literature (Bagiati, 2011; Cunningham, 2009; Stone-MacDonald et al., 2015), early engineering studies conducted with children and their parents (Smetana et al., 2012), and science and engineering education frameworks (NRC, 2011) were examined. Indeed, the critical knowledge and skills, which were introduced by the EiE team and essential to children's technological literacy and engineering education (Cunningham, 2009), were used as one of the main resources for the design of the knowledge and skills-related learning objectives of the EDCPI. According to the EiE team, children should know what engineering and technology mean, the place and importance of engineering and technology in our daily lives, the various areas of engineering, and the problems or needs they address, and the fact that engineers can be from different races or genders. As mentioned previously, the EiE curriculum addresses elementary level children (Cunningham, 2009). However, within the context of the EDCPI, these knowledge and skills were adapted to preschool children and extended by adding some indicators, because it was believed to be important for preschool children in terms of their engineering understanding and skills.

On the other hand, what the preschool children should know about engineering was not limited to the ones mentioned above. As Smetana et al. (2012) emphasize, children should recognize the instances of engineering in their daily life, at their home or school. In this way, their possible misconceptions about engineering may be changed. Furthermore, as stressed in the relevant literature (Davis et al., 2017; Smetana et al., 2012; Stone-MacDonald et al., 2015), engineering is a part of preschool children's daily life. Therefore, preschool children should know that the way they solve their problems is similar to the work of real engineers (Stone-MacDonald et al., 2015). In addition, as Bagiati's (2011) study signified, preschool children are able to demonstrate or declare their learnings about some engineering-related concepts, such as artifact, function, building, and construction. Concordantly, in the light of this relevant literature (Bagiait, 2011; Bers, 2008; Cunningham, 2009; Hill, Corbett, & Rose, 2010; McCue, 2016/2017; NRC, 2012; Smetana et al., 2012), some learning objectives with regard to helping preschool children identify the different engineering examples in our man-made world, making them more familiar with engineering concepts, and making engineering more relevant with their play and daily activities were added to the EDCPI (see Table 11).

Table 11

Learning objectives in the third prototype of the EDCPI within the knowledge dimension

Objectives	***Indicators***	***Resource***
K1: The child comprehends the meaning of engineering and technology (Cunningham, 2009).	Tells what engineers do	Bagiati (2011); Cunningham (2009)
	Tells what technology is	Cunningham (2009)
	Expresses that engineers are working to make human life easier and meet people's needs	McCue (2016/2017)
	Demonstrates knowledge about the steps followed by engineers during EDP	Bagiati (2011)
K2: The child recognizes the engineering products used in everyday life (Smetana et al., 2012).	Exemplifies technologies s/he sees around her/him	Smetana et al. (2012)
	Distinguishes natural objects from human-made objects	Bers (2008)
	Expresses that engineers design almost everything in our world that serves a final purpose	Cunningham (2009)
K3: The child discovers different fields of engineering (Cunningham, 2009).	Gives examples to technologies produced by engineers from different fields	Cunningham (2009)
	Explains how engineering is effective in many areas of the human world	Smetana et al. (2012)
K4: The child comprehends that everyone can be an engineer or think like an engineer (Cunningham, 2009).	Gives examples to engineers from different genders and to technologies they produced	Hill et al., (2010)
	Gives examples of situations in which s/he or someone around him/her thinks like an engineer and produces a solution	Smetana et al. (2012)
K5: The child comprehends the role of engineering and technology in the development of our world and society (Cunningham, 2009; NRC, 2012).	Explains how engineering and technology influence the world (positively or negatively)	Cunningham (2009)
	Compares today's conditions with those of the past when engineering and technology were not developed	NRC (2012)
	Gives examples of how engineering and technology affect our society (positively or negatively)	NRC (2012)

- *Learning Objectives in the Skills Dimension*

As Oh et al. (2016) highlight the fact that engineering means much more than just building things in a successful engineering learning experience. Unless children are allowed to engage in the cyclical process of engineering design, they cannot benefit from the advantage of engineering learning. Indeed, EDP includes a number of skills to be acquired by children. For this reason, one of the main objectives of EDCPI is to ensure that preschool children experience EDP and equip preschool children with engineering skills.

As in the knowledge dimension, learning objectives in the skill dimension of the EDCPI were determined after a detailed literature review (see Table 12). Indeed, the skills proposed by the EiE team shed light on EDCPI's engineering skills related learning objectives. As Cunningham (2009) stresses, elementary children should follow each phase of the EDP, reflect their science and mathematics related knowledge on engineering problems, solve problems by using their creative and carefull thinking, learn from their trial and errors, and comprehend the importance and features of materials to the engineering solution. Similarly, the performance expectations introduced for kindergarten children by NGSS (the NGSS Lead States, 2013) was one of the resources inspired from while determining learning objectives with regards to engineering skills. Indeed, the EDCPI learning objectives with regards to engineering skills were determined in parallel with NGSS kindergarten performance expectations.

Lastly, different steps and relevant tasks of EDP proposed by different enginering curriculums shed light on EDCPI in determining skills-related learning objectives (Bagiati, 2011; Cunningham, 2009; Lottero et al., 2016; Stone-MacDonald et al., 2015). Besides the engineering skills, EDP requires the use of some knowledge and skills in other STEM disciplines. Therefore, the last two skills of the EDCPI were determined as the main mathematics and science knowledge and skills expected to be acquired by preschool children in the light of the related literature (Fuson, Clements, & Sarama, 2015; Sylva, Siraj-Blatchford, & Taggard, 2006). A detailed and age-appropriate list of engineering skills was created after expert opinion was received and each learning objective was reviewed by considering the views of experts. Table 12 presents the version of the skills-related learning objectives in Prototype 2

Table 12

Learning objectives in the third prototype of the EDCPI within the skills dimension

Learning objectives with the resources taken as the base	***Relevant indicators with the resources taken as the base***
• S1: The child identifies an engineering problem which can be solved by developing an engineering product through observation and inquiry (NGSS Lead States, 2013; NRC, 2012).	• Identifies the problem or the need (Bagiati & Evangelou, 2016; Hoisington & Winokur, 2015). • Reviews her/his prior knowledge about the problem (Lottero-Perdue et al., 2016). • Asks questions about the problem (Stone-MacDonald et al., 2015) • Determines the problem-solving goal (Cunningham, 2009). • Identifies the constraints and criteria for solving the problem (Lottero-Perdue et al., 2016). • Explores available materials (Stone-MacDonald et al., 2015) in respect to the limitations of the problem.
• S2: The child develops possible solution idea(s) and reflects this/these on a simple plan and model (NGSS Lead States, 2013; NRC, 2012).	• Brainstorms ideas on how materials can be used and modified (Lottero-Perdue et al., 2016). • Brainstorms ideas on how the materials can be used together to solve the problem (Lottero-Perdue et al., 2016, p. 72). • Produces a solution idea to solve the problem (Douglass, 2016). • Draws a plan, creates a physical model, or verbally expresses how the solution will look and act (Kelley & Sung, 2017; Stone-MacDonald et al., 2015).
• S3: The child constructs her/his design and tries to improve it (Cunningham, 2009; NGSS Lead States, 2013; NRC, 2012).	• Follows the plan s/he drawn or expressed to solve the problem (Cunningham, 2009). • Chooses appropriate materials for the design by taking the constraints of the problem into consideration (Hoisington & Winokur, 2015). • Works collaboratively with her/his parents by using hands-on materials (Bagiati & Evangelou, 2016; Stone-MacDonald et al., 2015). • Constructs a design to solve the problem (Lottero-Perdue et al., 2016) or improves the model s/he created in the previous step. • After testing her/his design, s/he decides whether it solved the problem (Lottero-Perdue et al., 2016). • Describes what happened when testing and what the result refers to the next version (Lottero-Perdue et al., 2016). • Implements her/his improvement ideas to the solution (Stone-MacDonald et al., 2015). • Tests it again after the improvements until the design satisfies the goal (Bagiati & Evangelou, 2016). • The design complies with the limitations and requirements of the problem (Katehi et al., 2009). • Shares the final version of the design with other children and parents (Stone-MacDonald et al., 2015). • Compares her/his initial ideas and final prototype of her/his design by pointing differences between these two conditions (Bagiati, 2011).

Table 12

(continued)

• S4: The child comprehends that it is possible to solve a design problem through multiple ways (Cunningham, 2009)	• S/he explores the solutions produced by her/his peers for the engineering problem (Stone-MacDonald et al., 2015). • Except for what s/he designed for an engineering problem, it produces different possible solution ideas (Stone-MacDonald et al., 2015).
• S5: The child comprehends that the utilized materials and the features of these materials have a critical role in engineering solutions (Cunningham, 2009)	• Explains why s/he used specific materials in her/his designs (Hoisington & Winokur, 2015). • Makes explanations about the properties of the materials s/he used in prior and last designs (Hoisington & Winokur, 2015).
• S6: The child utilizes her/his math-related knowledge and skills (Fuson et al., 2015) to solve engineering design problems.	○ Utilizes his/her knowledge and skills about the subjects of the whole number, relations, operations (Fuson et al., 2015; Moomaw, 2013) to solve the engineering problem. ▪ Working with number (e.g. counting) ▪ Cardinality (e.g. knowing how many objects are in a set) ▪ Relations (e.g. establishing relations such as more than, less than, or equal to) ▪ Operations (addition and subtraction) ○ Utilizes his/her knowledge and skills about geometry, spatial thinking, measurement to solve the engineering problem (Moomaw, 2013). ▪ Having knowledge about space (below, above, beside). ▪ Having knowledge about two or three-dimensional geometric shapes (e.g. (e.g. "Look Mom, I combined two triangle blocks to make a rectangle roof"). ▪ Taking geometric shapes apart and putting them back to form new shapes. ▪ Utilizing mental representations of the environment ▪ Creating models representing relationships between objects in the environment ▪ Comparing lengths, heights, and other features by using standard or nonstandard measurement tools (NRC, 2009, p. 336).
• S7: The child applies her/his science knowledge to address an engineering problem (Cunningham, 2009)	• Utilizes her/his science-related knowledge (e.g. living/nonliving things, habitats, environmental needs and specific characters of plants and animals, characteristics and changes in the natural world, weather and seasons, natural materials, scientific concepts) (Moomaw, 2013; Sylva et al., 2006) during EDP.

- *Learning Objectives in the Dispositions Dimension*

Dispositions can be defined as "…habits of mind or tendencies to respond to certain situations in certain ways (Katz, 1994, p. 24). As Swanson and Ros-Voseles (2009) stressed, having a skill or knowledge about a subject does not necessarily end up with its usage.For example, most elementary school children can read, but some avoid it as much as possible. While the curricula are planned and teaching methods are determined, dispositions should be taken into consideration; thus, dispositions can come to light, be appreciated, and further improved and strengthened (Helm & Katz, 2001). Indeed, a proper curriculum which addresses young children should set sight on promoting their innate dispositions (Katz, 2010). For instance, curiosity is an in-born disposition for all children who possess the knowledge of the way things are made (Draper & Wood, 2017). Katz (1993) also emphasizes that the way to learn and strengthen dispositions, such as curiosity, creativity, and collaboration, which preschool children are required to learn, is to observe people who demonstrate these dispositions. Similarly, dispositions are strengthened by means of settings in which the child has the opportunity to exhibit her/his own dispositions and to observe that her/his dispositions are appreciated. Indeed, exploring the environment around them and finding out various cause and effect relationships are innately desired by all children. In this context, pedagocial methods addressing preschool children should foster children's main dispositions and give children the chance to demonstrate their dispositions and observe people who possess these dispositions (Katz, 2010).

EDCPI learning objectives in the dispositions dimension include some of the thinking skills likely to be exhibited by children in EDP (curious, persistent flexible, reflective, and collaborative thinking). Indeed, having and displaying these thinking skills is a necessity to be successful in EDP for both engineering designers and children who engage in the problem-solving process (Stone-MacDonald et al., 2015). These five thinking skills were handled in EDCPI as dispositions exhibited in EDP (Stone-MacDonald et al., 2015). While the indicators of these thinking skills were established, the indicators identified by Stone-MacDonald et al. (2015) were mainly grounded on. In addition, indicators in the literature regarding the characteristics of those who demonstrate these thinking skills were included in the learning objectives (Bagiati & Evangelou, 2016; Barak & Levenberg, 2016) (see Table 13 for its form in the third prototype of the EDCPI).

- *Learning Objectives in the Feelings Dimension*

As Katz (2010) stressed, feelings is the other dimension of learning in early childhood. Children who experience engineering design activities may experience some positive and

Table 13

Learning objectives in the third prototype of the EDCPI within the dispositions dimension (Stone-MacDonald et al., 2015).

Dispositions	*Indicators*
Curious Thinking	• Shows interest in learning new things and trying new experiences. • Makes observations and poses questions about observable situations. • Becomes increasingly independent in her/his selections. • Shows a willingness to learn various topics and ideas. • Poses questions to obtain information. • Plans and carries out investigations utilizing simple equipment. • Investigates and finds out the ways to produce solutions to the problems. • Benefits from various resources to explore answers to questions.
Persistent Thinking	• Makes many trials until s/he reaches success. • Designs and carries out a plan to solve a problem. • Continues to plan and pursue her/his aim until s/he reaches it. • In spite of redirections or distractions, s/he can recollect her/his attention for a long time in the design process. • Tests his / her solutions and makes changes on the design / model according to the test results. • Appeals for help when s/he encounters a problem.
Flexible Thinking	• Suggests different ways of solving a problem. • Represents his/her idea of a solution by means of a sketch, a model, or verbal expression before trying it. • While trying to solve a problem, s/he exhibits imagination, inventiveness, and the ability to adapt to new situations. • Observes and inspires other people's ways of solving problems. • S/he is open to the opinions and suggestions of parents or peers. • Adapts to new people and situations through minimal assistance. • Solves problems without being obliged to try all the possibilities. • Implements her/his ideas to new situations. • When s/he fails during trials, s/he focuses on developing her/his current design instead of making a new one. • Thinks on the problems by considering the various possibilities and by analyzing the results. • Uses different sources (e.g. books, images, videos) to solve the problem.
Reflective Thinking	• Documents his/her experiences and thoughts. • Talks about his/her experiences to evaluate and understand them. • When support is provided, s/he remembers her/his personal experiences and their sequence. • Uses her/his knowledge of daily experiences in the new context. • Establishes theories based on experience with regard to what might happen. • Supports her/his thoughts with evidence.
Collaborative Thinking	• Recognizes and acknowledges that other people's feelings and thoughts related to a situation might differ from his/her own ones. • Waits for her/his turn while working on a task. • Interacts with her/his parents and peers in the group to plan, coordinate roles, and cooperate on the task. • Communicates her/his thoughts about a task to her/his parents and her/his peers. • Negotiates with the group members to resolve conflicts in a task. • Understands group members' basic emotional reactions and their reasons. • Shows interest in others' feelings.

negative feelings about learning engineering. Bagiati (2011) revealed that, preschool children may experience some positive feelings during EDP such as being enthusiastic about participating in engineering-related activities and discussions, proud of self-achievements, frustrated with failure, pleased about working with her/his parents during EDP, and satisfied with collaborations. Preschoolers might also experience some negative feelings, such as getting bored with the activity and being easily distracted, becoming frustrated with collaborations and engagement, and developing a liking or disliking for the resources they are provided with during the engineering design activities (Bagiati, 2011; Bagiati & Evangelou, 2018). During the implementation of EDCPI, preschool children are engaged in EDP with the accompaniment of their parents. Therefore, children's feelings about both engineering learning and working with their parents are thought to be very important in their learning and handled as another dimension of EDCPI learning objectives. In this context, preschool children's both possible positive and negative feelings about their engineering learning experience and about engineering as a discipline were found worthy to investigate. Therefore, some learning objectives relevant to feelings for engineering were determined in the light of relevant literature (Bagiati, 2011; Davis et al., 2017) (see Table 14 for its form in the third prototype of the EDCPI). In this respect, attention was paid to the observation of both positive and negative feelings in the process, but the curriculum objectives included only positive feelings.

Table 14

Learning objectives and possible negative feelings taking place in the third prototype of the EDCPI within the feelings dimension

Learning Objectives	***Indicators***	***Resource***
• F1: The child likes to work as an engineer.	• S/he appears enthusiastic to participate in engineering activities. • S/he participates in activities without being distracted.	Bagiati & Evangelou (2018); Davis et al. (2017).
• F2: The child likes to help people or characters who have a problem.	• S/he is interested in the problems of the parrot and his/her friends. • S/he seems happy to produce solutions to the problems presented to him/her.	Davis et al. (2017).
• F3: The child is pleased by work with her/his parent.	• S/he seems happy to experience EDP with his/her parent(s).	Bagiati (2011); Bagiati & Evangelou (2018).
• F4: The child is pleasured by use open-ended materials in engineering activities.	• S/he seems pleased to make designs with open-ended materials. • S/he seems excited to discover open-ended materials to be used in engineering design activities.	Bagiati (2011); Bagiati & Evangelou (2018).

Table 14

(continued)

• F5: The child is proud of himself/herself and his/her parent because they create a design of a solution to the problem offered to them.	• S/he seems happy with her/his success while presenting her/his design and telling her/his engineering process to other groups. • S/he seems happy when s/he tells other groups and teacher how his/her design will solve the problem.	Bagiati (2011); Bagiati & Evangelou (2018).
• F6: The child considers engineering as a possible career.	• S/he says that s/he can be an engineer when asked about which profession s/he wants to choose.	(Cunningham, 2009).
• Negative Feelings (NF1): The child appears bored of the activity.	• S/he says that s/he wants to go home or gets bored while the activity is in progress. • S/he leaves the activity and engages with other things.	Bagiati (2011); Bagiati & Evangelou (2018).
• NF2: The child indicates disappointment due to failure.	• S/he seems frustrated when s/he and her/his parent(s) fail to resolve the problem presented to them.	Bagiati (2011); Bagiati & Evangelou (2018).
• NF3: The child seems disgruntled to work with open-ended materials.	• S/he expresses that s/he does not want to use the open-ended materials that are offered to make designs during the activity. • S/he expresses her/his desire to use other materials to replace the open-ended materials presented to them.	Bagiati (2011); Bagiati & Evangelou (2018).

3.2.1.3 Determining Main Learning Concepts of the EDCPI

After the draft learning objectives of the EDCPI were determined, the next step was to determine what children would learn within the context of this curriculum (van den Akker, 2013). In this way, the researcher identified some learning concepts to be included in EDCPI learning activities. In this process, a review of the relevant literature enabled the study to explore which STEM concepts could be introduced to preschool children. In this regard, EDCPI learning concepts were guided by some crosscutting concepts introduced by NRC (2012) (see Table 15), and engineering concepts and terminologies (e.g. design, engineer, engineering, plan, model) were introduced by Bagiati (2011). Although EDCPI is an engineering education curriculum and includes engineering design activities, it aims to improve children's knowledge and skills in not only engineering but also other STEM fields by regarding learning from an interdisciplinary viewpoint. At that point, it was thought that the crosscutting concepts served as a bridge between disciplinary frontiers and had an explanatory value for both science and engineering. These concepts could help to create an organizational framework for students to connect the knowledge from various disciplines with a coherent and scientific view of the world. Therefore, some of the crosscutting concepts were grounded on while determining EDCPI concepts. In addition, the lesson plans developed by Bagiati (2011) and aimed at teaching preschool children about engineering concepts and terminology in a developmentally appropriate way guided the researcher. Indeed, by means of EDCPI, the aim was to allow preschool children to experience the steps of EDP and make them familiar with some engineering related concepts and terminology. At this point, the concepts and terminology used by Bagiati (2011) shed light on the definition of learning concepts (e.g. plan, model, sketch, engineering, design, test) in EDCPI, and the definition of these concepts in a developmentally appropriate way to children during the learning activities.

Once the content of the EDCPI was determined, it was time to plan how, where, when and with which materials this content would be taught. All these components of the curriculum were determined through activities performed by the researcher in the preliminary phase. These activities are explained in the following section.

3.2.2 Phase II: Prototyping Phase

Prototyping refers to the evaluation and revision of design products in a systematic process to solve real life problems (van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). In the prototyping phase of the current study, feedback obtained from the experts, the collaborative works with the design support team and the teachers, and the findings obtained from the iterative practices contributed to the development of the intervention. Following subsections present information about each of these micro-phases carried out in prototyping process, the procedures followed by the researcher during each micro-phase and the identification of practicality and effectiveness issues of EDCPI.

3.2.2.1 First Iteration of the Prototyping Phase: Expert Appraisal

The draft version of EDCPI was designed by the researcher in line with the draft design principles and the findings obtained in the preliminary phase. Hereby, the iteration process of EDCPI, which would ensure that this draft design was refined and developed throughout the prototypes, was initiated (Wang et al., 2014). As the first step, educational goals of the curriculum that defined what knowledge and skills wanted to be achieved by preschool children at the end of the implementation were determined (Dick et al., 2015). Based on the relevant literature, the draft version of the learning objectives and the relevant indicators expected to be reached by preschool children and their parents through the EDCPI were identified by the researcher. At that point, the existing engineering-related frameworks (Lottero-Perdue et al., 2016; Katehi et al., 2009; NGSS Lead States, 2013; NRC, 2012; Stone-

Table 15

Sample EDCPI learnig activities and related concepts

Activity	***Concepts***	***STEM-related concepts (NRC, 2012)***
"Do not let the parrot get wet"	Engineer, engineering, technology, design, sketch, plan, model, test	*Pattern* (Children recognize the pattern in EDP and orders the images representing the steps of EDP by considering this pattern.) *Scale, proportion, and quantity* (Groups measure the sizes of the roof by considering standard and non-standard assessment tools.) *Cause and effect: Mechnanism and prediction* (Groups test their design solutions and think about the test results through questions such as "Why didn't your roof let the water in? or "What caused the roof to let the water in?") *System and system models* (Each group expresses their solution ideas by means of drawings and sketches, and/or oral definitions. They also create a model reflecting a system. They explain their design, the parts the design contains, and the function of each of these parts).
"Can the turtle cross the river?"	Engineer, design, sketch, plan, model, test	*Scale, proportion, and quantity* (Groups measure the height of the river and the weight of the turtle by considering standard and non-standard assessment tools. Therefore, they can design a bridge that can carry the turtle and allow it to cross the river). *System and system models* (Each group expresses their solution ideas by means of drawings and sketches, and/or oral definitions. They also create two models reflecting a system. They explain their design, the parts the design contains, and the function of each of these parts). *Cause and effect: Mechnanism and prediction* (Groups test their design solutions and think about the test results through questions, such as "Why did the turtle fall into the water?", "Why didn't your bridge carry the turtle?" or "What are the basic conditions for the turtle to pass from one end of the river to another?") Energy and matter: Flows, cycles, and conservation (A major goal in design is to maximize certain types of energy output while minimizing others, in order to minimize the energy inputs needed to achieve a desired task (NRC, 2012, p.95) By focusing on the use of the bridge in our daily lives, it is possible to raise awareness among children about the bridges being able to profit from energy. They also design a bridge for the old turtle and enable the turtle to cross the river by spending less energy). *Structure and function* (Children can discover how shape and stability are interrelated for various structures or purposes. For instance, they design their bridges in different shapes (for instance some of their designs are like an arch bridge, while some of them are like suspension bridges etc.).
"The marble carriers"	Engineer, design, sketch, plan, model, test	*Scale, proportion, and quantity* (Groups measure the height of the bird house by considering standard and non-standard assessment tools. Therefore, they can design a system that can uplift three marbles to the parrot's house). *System and system models* (Each group expresses their solution ideas by means of drawings and sketches, and/or oral definitions. They also create a model reflecting this moving system. They explain their design, the parts the design contains, and the function of each of these parts). *Cause and effect: Mechnanism and prediction* (Groups test their design solutions and think about test results through questions such as "Why didn't the marbles fall down?", "How did our system work?", "Why didn't your system carry the marbles?") *Structure and function* (Children design a moving system with different shapes and parts of this system with different purposes. Therefore, they experience the relationship between stability and shape by means of their designs).

MacDonald et al., 2015) and curricula (Bagiati, 2011; Cunningham, 2009) addressing preschool, kindergarten, and elementary children guided the researcher. On the other hand, it was thought that this intervention might have some contributions for parents as well as children. Therefore, the learning objectives of the EDCPI and their indicators were constructed within two dimensions, namely as parent-related and child-related learning objectives. As in the child-related learning objectives, the parent-related learning objectives were identified under the guidance of both relevant literature (Dorie & Cardella, 2014; Dorie et al., 2014; Ihmeideh & Oliemat, 2015; Smetana et al., 2012).

After the researcher and another researcher from the design support team discussed this draft version and finalized it to receive expert opinion, the two experts evaluated the EDCPI learning objectives and provided feedback. These experts were particularly chosen because they were both developers of two major engineering curricula developed for preschool children in the literature. One of the experts was from the field of engineering and the other one was from the field of education. The experts provided the researcher with evaluation on this first version of the EDCPI learning objectives in terms of their appropriateness for the preschool age group, and their clarity and relevancy. Based on the feedback obtained from these two experts, the researcher modified the EDCPI learning objectives.

As a second step, the learning objectives and the draft design principles of the curriculum were revised after the expert evaluation, the draft version of the five curricular activities, and the other components of EDCPI (the role of teachers and parents in these activities, the learning materials and resources to be used, the place and time of activities, and assessment tools) (van den Akker, 2013) were designed. All these processes are explained under the following sub-headings.

3.2.2.1.1 Design of the EDCPI Learning Activities

The EDCPI learning activities were designed under the guidance of the draft design principles identified in the light of the relevant literature. In addition to draft design principles, while designing the EDCPI learning activities, the nine events of the instruction proposed by the Gagne (1985) was adopted by the researcher as an instructional strategy (Dick et al., 2015; Gagne, Wager, Golas, & Keller, 2005):

- *Gaining attention to ensure the reception of the stimuli* : The engineering problems in EDCPI activities were presented by means of various stories that were explained through puppets to generate children's motivation and arouse their interest. In addition to the puppets, various visuals were used to explain and exemplify some concepts (e.g. bridge, roof, pollution). Finally, during the implementation of the fifth activity of

EDCPI, a video was shown to the children and their parents to make the concept of the chain reaction clear.

- *Informing learners about the purpose to create appropriate expectations*: In each activity, effort was made to get children to solve the different problems of a character by experiencing EDP. During the implementation of each activity, attention was paid to ensure that children were informed about the objective of solving the problem. This was ensured by asking questions to the children in different steps of the EDP and by getting their feedback (e.g. "To whom do you design this bridge?; What problem are we trying to solve today?").
- *Reminding prerequisite learning*: In the introduction of activities, the children's prior knowledge was examined through various questions, and they were provided with the opportunity to remember the preliminary information necessary to solve the problem.
- *Providing children with stimulus materials*: Both the process they would experience and the engineering concepts (e.g. bridge, roof, system) were presented to the children by using visuals and videos to stimulate their interest. Besides, in order to construct their designs, children were provided with open-ended materials, which are strong stimuli and support preschoolers' creativity, imagination, and inventiveness (Kiewra & Veselack, 2016; Neill, 2013).
- *Providing guidance*: EDCPI activities were prepared in a way that parents could guide their children's learning process. In addition, in the EDCPI activities, the teacher served as guide parents and children by monitoring their work during EDP and by asking questions.
- *Eliciting the performance*: EDCPI activities were designed to give children the opportunity to demonstrate their engineering thinking and skills by actively participating in EDP. The learning process was also fed with a variety of questions which aimed to elicit children's responses, and thus, to determine uncertainty and misunderstandings.
- *Providing feedback to the learners about the performance*: The learning process in the EDCPI activities was designed in a way that the information related to the accuracy of their understanding and performance was provided to the parents and children. For this purpose, each parent-child group was observed, and feedback was given individually by the teacher during the design process. In addition, the teachers were informed about the fact that they should pay attention to eliciting from each child the answers to the questions asked during the activities and giving feedback about the accuracy of each response.

- *Assessing the performance*: EDCPI was based on the individual assessment of the performance demonstrated by each child. This assessment was performed by means of the child observation form and groups' classroom work.
- *Arranging diverse practice to facilitate future recall and transfer:* EDCPI was planned as a weekend PI activity that would reinforce what was learned during the week, as most parents worked during the week. Therefore, by its nature, EDCPI provided children with spaced practice, which might reinforce what was learned. In addition, the content was designed to enable children to transfer the knowledge and skills they learned to a different problem presented the following week.

In the curriculum prepared by considering the abovementioned actions, each of the learning activities was designed to provide preschool teachers with an introduction to the EEE and support them through procedural specifications about how to implement engineering activities. To this end, activity templates were structured based on four main parts, and regarding these four parts, teachers were provided with concrete explanations about a brief description of the activity, preparation for the activity, subject content, teaching strategies and assessment of children's learning. For this reason, the activity templates were designed to include a detailed description of the learning process aimed at guiding preschool teachers in implementing EDCPI. Table 16 presents an overview of the format and design specifications utilized to design the prototypes of the EDCPI learning activities in the current study.

As for the design of the learning process of the EDCPI activities, all the activities were structured with the same flow. At that point, the four steps EDP model utilized in the prsent study (think about it, try it, fix it, and share it) (Stone-MacDonald et al., 2015) and the skills-related learning objectives of the EDCPI guided the researcher. First of all, each activity starts with an introduction part. In the first two activities, the introduction part starts by informing the groups about the definition of engineering and the work of engineers. In the next three activities, children are reminded of what engineers do and the technologies they produce through the questions directed to them. In other words, in the introduction part of the activities, which aim to provide children with knowledge-related learning objectives of the EDCPI, children were informed about engineering. Children were provided with the knowledge of the meaning of engineer, engineering and technology, and their importance in our world by means of instruction and discussion in this part. The second activity begins by reminding children what the problem of the previous activity was and which stages were experienced to solve the problem.

All the EDP steps are remembered by examining the engineering notebooks. Then, the problem for which solutions were expected to be produced on that day was presented to the groups by means of a story and by using hand puppets (parrot and turtle). To address children of different genders and to avoid creating any misconception about the gender of engineers in children, puppets were designed by the researcher as gender-neutral (see Figure 15).

Table 16

Sample activity template of the EDCPI

Definition of the activity	*Brief explanations about what the learning activity looks like* • The name of the activity • Focused thinking skill • A brief explanation of the aim and focus of the activity *Learning objectives* • Objectives and indicators related to learning in engineering • Objectives and indicators related to ECE curriculum *Learning concepts* • Engineering concepts • Concepts that are targeted with the activity and compatible with the existing ECE curriculum.
Preperation	*Materials* • Required materials for the activity • Possible materials that may be alternatives to the materials on the list *Motivating children to the activity* • Example strategies to motivate children to the activity
Learning process	*Subject content* • Clear and detailed explanations of how each step of the EDP will be followed in the activity flow. • Examples of questions the teacher may ask children to reveal their prior knowledge about the problem • A clear and detailed example of the statements to teach STEM-related learning concepts in the activity • Sample strategies (e.g. using visuals) can be used to make the problem situtaion and constratints more clear for children *Teaching strategies* • Suggestions on some reinforcing activities to be carried out groups at their home • A clear flow among the steps of the EDP to guide the teacher in preparing similar engineering activities • Strategies to be a model for children in thinking skill targeted by the activity • Suggestions for creating a portfolio reflecting each child's learning process
Assessment	*Assessment strategies* • All groups share their experiences with each other and evaluate (verbally) each other's designs • Usage of protfolios in the assessment process • Suggestions for sample discussion questions concerning the subject content that can be used in large group discussions

Figure 15 The hand puppets designed by the researcher to be used in the study.

In order to have a clearer understanding of the problem, some concepts in the activity (e.g. roof, bridge, pollution) are presented through various visuals and hands-on experiences (e.g. throwing the marbles with the catapult, filtering the tea). In the fifth activity, besides, the groups were shown a video about the chain reaction so that they could understand the Rube Goldberg system. The link of the video is presented at the relevant activity template. Therefore, children's prior knowledge is stimulated by means of various questions. After the problem is presented, the second part aims at ensuring a thorough understanding of the problem. The groups are clearly explained what the problem is (e.g. "Today we will work as environmental engineers and think about ways to clean up the Green River") and what is expected from them (e.g. "The turtle and I expect you to make a filter that can clean the Green River from waste.")

In the third part, by considering the various limitations, the limitations of the problem of that day are explained to the groups. In the next part, each child draws the plan of her/his own solution idea/ideas and explains this plan to the teacher. Then the groups create a model to represent their solution idea in a three-dimensional form with the materials they selected. In the next part, groups test the models they created in terms of the constraints of the problem. The next part involves constructing a design. In this section, the groups can develop their models if they want or they can build a different design from the model. In the next part, the groups who want to try out their design test their designs to see if it has solved the problem. In the meantime, the teacher guides the process by asking various questions. The groups who test their design produce and implement ideas to improve their designs based on the results of the tests. The trials continue until the design is successful. In the last part, groups share their own design ideas with the other groups. Meanwhile, each child can share his/her own design process with the others by means of verbal expressions, or explain by showing his/her plan, model and design. If s/he wants, the child can do a trial in front of other groups to explain the working system of her/his design. In this way, all groups see and evaluate each other's design ideas and make suggestions towards improving the design. At the end of the learning process, what was learned that day, what steps were taken during the design process, what the solution to the problem was, and what was done to solve this problem were summarized and reviewed together with the children. All these components of the activity flow are summarized in Figure 16.

The learning activities within the EDCPI were designed to follow a sequence from simple to complex. In the first activity which focused on especially one feature of the materials (waterproofness) and aimed to introduce the steps of the EDP to the children and their parents, the groups designed a waterproof roof for the parrot's house. In the second activity, which involved building a bridge over the river for the turtle, the groups were expected to focus on more than one multiple constraint (to be able to carry the turtle; to be wide enough for the turtle to pass; to be able to enable the turtle to cross the river from one end to the other). In this respect, the second activity is a relatively difficult activity compared to the first activity. In the third activity, the groups were expected to design a system to uplift three marbles to the parrot's house, which was approximately 50 cm above the ground. It was thought that producing a system idea and making it a reality was more difficult than the design ideas and products in the first two activities. In the fourth activity that involved a variety of scientific concepts which seemed abstract for the preschool children (e.g. buoyancy of water and environmental pollution), groups were engaged with inventing a filter to clean the river. This activity also required to pay attention to multiple aspects of the materials (e.g. waterproofness, size, and filtering feature). In this respect, it was considered a fun and challenging activity for the child who had experienced EDP in previous activities and had become accustomed to the process. Finally, the fifth activity involved creating a group of different parent-child groups and designing a system which could take the parrot’s car to the repairman. In other words, the last activity required group work. In fact, this activity is considered a more difficult activity than the others because it can be challenging for the preschooler child to make common decisions with the other group members, to express their opinions within the group and to be open to the ideas and suggestions of others.

Another issue that was taken into consideration when designing the activities was to exemplify the various branches of engineering. In fact, except for the fifth activity, all the EDCPI activities aimed to enable children to have knowledge of different fields of engineering and experience these fields in an appropriate way to their ages. In this regard, in the first and second activities, civil engineering, which engages in designing and building public structures, is addressed. On the other hand, in the third activity, children are asked to be an industrial engineer and design a system which can make the work of moving the marbles easier for the parrot. In the fourth activity, children produce solutions to water pollution in the river by designing a filtering system. In this way, children experience environmental engineering which engages them in solving problems occurring in the natural environment (Katehi et al., 2009).

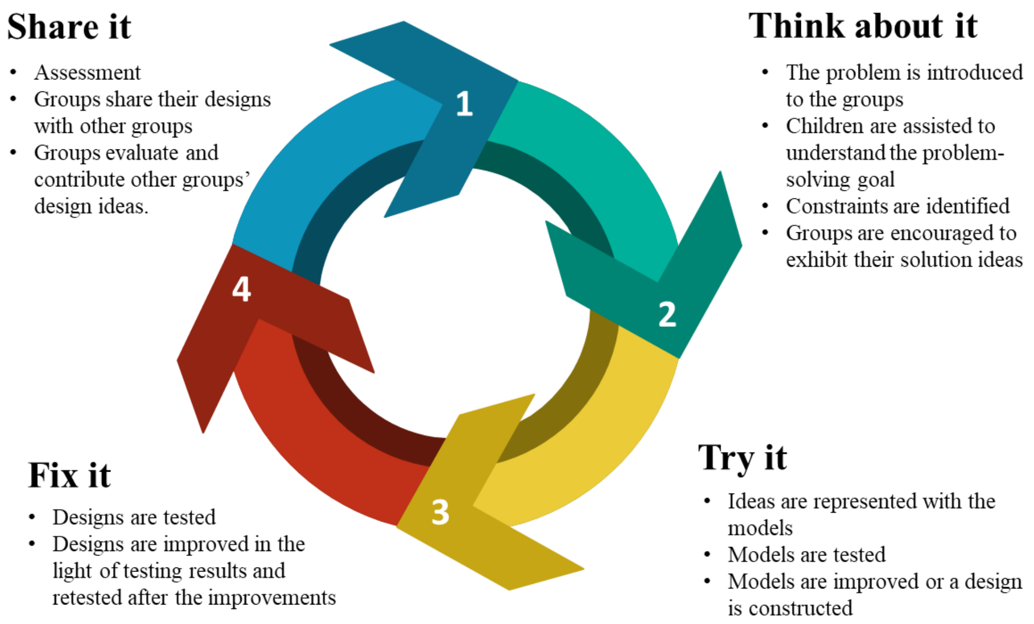

Figure 16 The flow of the activities structured around the four main steps of the EDP.

Finally, as mentioned earlier, each of the five learning activities in EDCPI was planned to focus on children's different thinking skills. Therefore, one of the issues considered in designing activities was thinking skills. The focus of the first activity was curious thinking. As Stephens (2007) stressed, one of the best skills that can be fed by adults is to guide preschool children to learn through discovery to satisfy their curiosity. Indeed, children’s curiosity and creativity were the starting point of this study. Therefore, engineering activities within the EDCPI aims to nurture preschool children’s curious thinking skills by presenting them with different engineering challenges and engaging children in EDP. For this purpose, the first activity of the curriculum was prepared by focusing on curious thinking and many questions that can be asked by the teacher in order to encourage curious thinking are included in the flow of activity. It is expected that the teacher will encourage children to question, wonder and seek for the answers of their questions through the exploration and hands-on experiences.

Another thinking skill that was aimed to be demonstrated and developed by children during the activities was persistent thinking. EDCPI activities were designed in a way that enabled them to test their solutions under the guidance of their parents, to improve and retest the solution in line with their ideas produced according to the test results. In addition, in the training conducted before the implementation, both parents and teachers were informed about they should encourage children to test, to question the results of their testing, to produce new ideas and to try again and again. Besides, considering the possibility of children who have never been involved in engineering or STEM in the classrooms where the curriculum to be implemented after the study, the first activity of the curriculum is focused on children's engineering understanding and EDP. Then, as of the second activity, children were encouraged to question more in their trial-and-error, to get the idea that our mistakes taught us new things, to not give up in case of failure and to develop their designs. For this reason, sample questions that could be asked by the teacher to foster children's persistent thinking were added to the activity flow of the second activity and children’s persistent thinking was specifically observed by the teacher and researcher.

In the third activity of EDCPI flexible thinking was focused on. In fact, all activities within the EDCPI were designed to enable each group to follow their own path to the solution of the problem. In this way, there would be many different solutions and groups would realize that there were multiple solutions that could be followed in solving the same problem. In addition, the focus was on encouraging children to see the current situation after every trial-and-errors during the EDP, to produce new ideas, to think about various possibilities and to be open to their parents' suggestions and feedback. However, specifically in the third activity, children were challenged to think about alternative solutions to move the marbles to the parrot’s house hanging on a tree and produce more than one solution idea. Each group was expected to reflect more than one solution idea into their plan and to design and try one of them, which they thought would be a better solution for the problem. In addition, during the presentations, which is the final stage of the activity, children were encouraged to explore and evaluate each other's design ideas, the materials they used and the working system of the designs. Sample questions that can be asked by the teacher to guide these discoveries and evaluations are included in the activity template. At this time, indicators for flexible thinking skills exhibited by children were observed.

The focus was the fourth activity was reflective thinking. Therefore, observations carried out on indicators of reflective thinking. On the other hand, all the activities of the

EDCPI were designed in a way including some strategies proposed by Epstein (2003) to foster children's reflective thinking. In this context, reflection was included in the activity flows as an ongoing part of the design process. After each stage of the EDP, the teacher goes to the children one by one and to review their plans and experiences with them. In order to be asked by the teacher during this review, some open-ended questions starting with "what, how, why" were added to the templates. Such type of open-ended questions can enable children to reconstruct their knowledge and to make sense of their experiences. In addition, by considering that some children might express what they did through gestures and facial expressions, some expressions were added to the activity templates to guide the teacher in interpreting and expanding these (e.g. I see you drew a plan for your roof. What's the shape of the roof you're planning to build? You say you will build a triangle roof. So, which materials do you plan to use to build this roof?). Finally, enabling children to remember their plans by considering their real designs can make possible for them to establish cause and effect relationships and to be able to take responsibility for their behavior. The aim is to make children think about the reasons and process of their actions rather than to hold them responsible for their plans. Their change of plans is completely acceptable. In fact, the goal of the design process is to make changes in line with the testing results on plans and designs to improve the design. What is important is to understand the logic of the change and to encourage children to think about their alternatives, choices, and strategies they used in the problem-solving process (Epstein, 2003). To this end, some questions have been added to the fourth activity template to guide children to reflect on their design process and the changes occurred in their ideas (e.g. I remember you drew a helicopter in your plan to move the marbles to the parrot's house. Is this the helicopter you drew in your plan? I remember you used cardboard when you modeled the roof, but I see that you've done the design with another material. What is the material you are using? Why did you stop using cardboard?).

The fifth activity of the EDCPI focused on collaborative thinking of preschool children. Therefore, the activity was designed in the way allowing children to collaborate with each other and their parents. In fact, in the first four EDCPI activities, while the focus is the collaboration among the parents and their children, the fifth activity is based on the collaborative work of more than one parent-child group to solve the design problem.

After designing the content of the activities, the roles expected to be undertaken by the parents during the intervention were identified. The following section describes these roles.

3.2.2.1.2 Identifying the Role of the Parents in the Learning Process

After the learning activities were determined, the next step was to identify parents' role in the learning process. In this regard, for the draft version of the EDCPI, the following roles to be undertaken by parents were identified:

- to guide the child during the learning process. This guidance should be provided mainly by the parent by being a model to their child in such skills as questioning and thinking (Murphy & Messer, 2000).
- in case of failure, to encourage the child to think about where the mistake or deficiency is and to try over and over again
- to intervene in the child's learning process only in circumstances when the child cannot deal with the situation without an adult's assistance (Wood, Bruner, & Ross, 1976). For example, if a child has not previously experienced measuring, s/he may not know how to use the measuring tool (e.g. a ruler or tape measure) and/or may have difficulty in recognizing the numbers on the measuring instrument. In such a case, the child needs an adult's guidance to acquire the measuring skill.
- to gradually decrease the support as the child gains expertise in a skill (Santrock, 2011). However, this does not mean that the parent should guide the child in the first weeks' activities, but should remain passive in the following weeks. The role of the parent should be to observe her/his child and be able to provide the necessary support when the child really needs it. This support can sometimes be a question to encourage a child to think, sometimes to respond to a call for help from the child, and sometimes to give an example to help the child connect what s/he learned in daily life.
- to be responsive to the child's ideas and questions, and encourage the child to actively think, explore, design, and test her/his solution ideas (MacNaughton & Williams, 2008; Stone-MacDonald et al., 2015).
- to support the child's engineering education at home by guiding the child to do her/his homework given within the scope of EDCPI and by reinforcing the learnings occurring with the implementation of the EDCPI and within settings outside the school (e.g. a spontaneous discussion on a question posed by the child about bridges during a car trip) (Dorie & Cardella, 2014; Epstein et al., 2009).
- to be open and willing to learn the strategies needed to guide the learning process of the child and also the knowledge and skills that are new to them (OBADER, 2013) at EEE.

- to be aware that her/his ideas are needed to improve the curriculum and share their suggestions and ideas with the researcher in the evaluation of the curriculum (Epstein, 2010).

3.2.2.1.3 Design of the EDCPI Assessment Tools

In the next step, the focus was the question of how to determine to what extent the curriculum objectives were achieved. In this context, an observation form based on the learning objectives of the curriculum was designed to measure children's competence to perform what was described in the objectives (Dick et al., 2015). Therefore, the child observation form was prepared in parallel with the learning objectives of EDCPI in the knowledge, skills, dispositions, and feelings sub-dimensions, which allowed the teacher and researcher to assess children in EDCPI learning activities. This form also allowed to determine the extent to which the learning objectives were achieved with EDCPI and to revise the learning objectives.

The form consisted of four parts. The first part included engineering knowledge-related learning objectives. In the second part, learning objectives and indicators that children were expected to reach in relation to their engineering skills were included, while in the third part, indicators for the thinking skill were focused on during that week's learning activity. Lastly, in the fourth part, EDCPI's objectives and indicators about the children's feelings were included (for the final prototype of the learning objectives and indicators see Appendix K). In the present study, children were assessed by the researcher in the knowledge dimension through pre-post-interviews in order to see children's initial and last knowledge level of engineering. Besides, both the researcher and the teacher assessed the children in the dimensions of skills, dispositions, and feelings in light of their observations which they carried out during the implementation of the activities. A major emphasis was put on relating the learning objectives of the curriculum to the assessment requirements (Dick et al., 2015). To ensure this relation and the validity of the observation form, expert appraisal was applied.

After all the activities and related learning objectives were formed in detail, the first prototype was evaluated by means of expert consultation. In this way, it was aimed to explore the validity of the EDCPI content. In this regard, four experts were consulted individually to receive their appraisals. One of the experts was in the field of early childhood education, while the second one was in the field of engineering education, the third was in the field of science education, and the fourth was in mathematics education. The content of the EDCPI was sent to the experts in the form of two different documents simultaneously. The first document included the first prototype of child and parent-related learning objectives and of the interview protocols. This document also included the child observation form that could be used to assess the extent to which the child had reached the learning objectives for engineering-related skills, dispoisitons and feelings. On the other hand, the second document included the first prototypes of the five learning activities within the EDCPI.

To determine the validity of the EDCPI content and to provide evidence of its relevance, the experts were asked to examine these two documents from various aspects, such as the accuracy of the content, whether it was clear and understandable, and its pedagogical appropriateness (Dick et al., 2015). Experts were also asked to review the documents, taking into account the suitability of the science, engineering, and mathematics language and the learning materials used in the learning activities, the flow of learning activities, and the assessment tools to measure the relevant learning objective. In general terms, experts conveyed that content and learning activities of the EDCPI were structured adequately to reach the determined learning objectives. On the other hand, they pointed out some aspects that should be revised while developing the prototype. For example, they pointed out some expressions (e.g. examples given to wastes in the fourth activity) that should be re-organized in terms of the use of scientific language in the explanatory parts of the activities. In a similar vein, experts commented that the interview questions also needed some revision. For example, the experts pointed out that after asking the children whether both women and men would be engineers (see Appendix A) while giving examples of inventions developed by female engineers, samples that could lead to any gender-related stereotype (e.g. dishwasher) should be avoided. In addition, the expert from the field of mathematics education drew attention to one of the mathematics related learning objectives of the EDCPI. According to her/him, the expression of "two or three dimensional shapes" needed to be defined more operationally. Besides, another expert stated that parent, child, and teacher pre- and post-interviews should include probing questions to obtain more detailed information from the interviewee (Taylor, Bogdan, & DeVault, 2015).

After the formative comments of the experts concerning the EDCPI content were received, revisions were made in the first prototype in the light of these comments and suggestions. Collaborating with not only practitioners but also experts contributes to the refinement of the curriculum and aids to develop more proper steps to solve content-based issues (Cobb, Confrey, DiSessa, Lehrer, & Schauble, 2003). Therefore, by means of the revision of the first prototype in the light of the expert appraisal, the formative evaluation cycles in the prototyping phase were initiated. The first cycle led to the second prototype (Mafumiko, 2006).

3.2.2.2 Second Iteration of the Prototyping Phase: Micro-Evaluation

In this DBR, the formative evaluation process of the prototypes was continued with the micro-evaluation study of the Prototype 2, developed by the researcher in the light of the feedback from the experts. The modifications made in the direction of the expert opinions are addressed in the findings chapter of the present study. The aim of the micro-evaluation study was to investigate the validity and expected practicality of EDCPI in ECE environments and to improve the EDCPI in line with the data obtained from this first implementation.

3.2.2.2.1 Participants of the Micro-evaluation Study

The micro-evaluation study of the second prototype was carried out in the spring semester of the 2017-2018 educational year with a preschool teacher working in a public preschool, eight children in the classroom of this preschool teacher, and the parents of these children. In this preschool institution, in which children aged 36-72 months were enrolled, there were nine classrooms and approximately 20 children in each classroom. This institution was located in the city center of Kastamonu province and varied in terms of parent profile. In other words, the parents whose children were enrolled in this institution differed from each other in terms of educational level and socio-economic status. This variation in the profiles of parents was one of the motivations for choosing this ECE institution to conduct the study because EDCPI aimed at addressing preschool children with parents from different socio-economic levels and different educational levels. Indeed, this institution was purposively selected based on three reasons. The first reason was the willingness of the school administration to participate in such an educational study and their welcoming approach to experience new developing educational approaches in Turkey like the STEM. The second reason was the abovementioned variation among parents in terms of demographic characteristics. Indeed, observing cases with different characteristics, and testing whether EDCPI whether worked in educational settings with the participation of parents from diverse demographic characteristics provided the researcher with some insight into the usability of her design and the generalizability of her findings.

Finally, this preschool was selected because the participant preschool teacher was selected for the purpose. Indeed, Teacher 1 (T1) was quite eager to learn how to integrate engineering into early childhood classrooms. In addition, she was a master’s student in the field of education and had experience in how to conduct scientific research since she was conducting her own master's thesis. She was thirty six years old and had a bachelors’ degree from the department of early childhood education. In the semester when the study was conducted, T1 had seventeen years of teaching experience and there were twenty students in her class, ranging in age from 60 to 74 months. She had not participated in such a practice before and had no training on STEM education. However, she was involved in a project on values education.

DBR is based on the mutual and collaborative work of the educator and the researcher in the selection and design processes of the intervention (Stephan, 2015). The collaboration continues from the initial problem determination phase to the design and structuring of the intervention, implementation, evaluation and to the production of theoretical principles (Anderson & Shattuck, 2012, p. 17). Similarly, in the present DBR study, an informal interview conducted with the preschool teachers during the context analysis was the first step of the collaboration established between the teachers and the researcher. It shed light on the determination of the design problem. This collaboration was put into practice by means of the micro-evaluation and try-out study with a small sample of these preschool teachers. Before the implementation process, the participant teachers provided the researcher with information via an informal interview about their needs related to STEM education and the general characteristics of the children and parents in their classroom. In the following process, the cooperation between the researcher and the participant teachers contributed to the structuring of EDCPI. In fact, throughout the study, the participant teachers were regarded as permanent members of the research team assuming the major responsibility of implementing the intervention. Hence, after the participant teachers were determined, the teachers and the researcher started to work together. They met during some days of the week, discussed and revised the activity which would be held that weekend by exchanging ideas.

After the participant school and teacher for the micro-evaluation study was determined, the parents of the children in the teacher's classroom were informed about the study by sending them a parental consent form (see Appendix M). In addition to the information about the researcher, this consent form included explanations about the aims and the content of the study, and what would be expected of the parents and children during the process. In this way, volunteer parents and their children who were to participate in the study were identified. Eight parents (4 male and 4 female) and their children (2 girls and 6 boys) who filled in the form and expressed their willingness to participate in the study constituted the participants of the study (see Table 17).

Table 17

Characteristics of the participant children and parents

Child ID	***Age (month)***	***Child's Gender***	***Mother's Job***	***Father's Job***	***Mother's Educational Level***	***Father's Educational Level***
C1	70	Female	Tailor	Electrical engineer	Primary school graduate	Bachelor's degree
C2	64	Male	Housewife	Repairman	High school graduate	High school graduate
C3	63	Male	Housewife	Artisan	High school graduate	High school graduate
C4	74	Male	Housewife	Security staff	Primary school graduate	Associate degree
C5	64	Male	Officeholder	Officeholder	High school graduate	High school graduate
C6	69	Male	Housewife	Officeholder	Bachelor's degree	Bachelor's degree
C7	74	Male	Housewife	Cleaning staff	Illiterate	Primary school graduate
C8	69	Female	Art teacher	Coach	Bachelor's degree	Bachelor's degree

3.2.2.2.2 Micro-evaluation of the Prototype 2

The second prototype was implemented by T1 on three Saturdays (between 10:30-13:30) and the last two learning activities were carried out respectively on Thursday and Friday evenings (between 17:00-20:00) due to an excuse of the teacher. In other words, the micro-evaluation study lasted for 4 weeks in total and was performed in five sessions in each of which a different learning activity of the EDCPI was implemented. The parents were asked if they were available on these days and hours before planning to carry out the last two activities.

The micro-evaluation study was carried out in an available hall in the faculty where the researcher was employed because permission was not given to practice any research with parents in the real classroom environment in the city where the study was conducted. This hall was used as a drama class in undergraduate courses and was empty at weekends and on weekday evenings (see Figure 17). The tables and chairs, as many as the number of parent-child groups, were moved from other classrooms in the faculty to this hall before the parents and children arrived. Audio recorders were placed under the desk of each parent-child group so that the children would not be distracted. In addition, a video camera was placed in such locations that all the groups and the teacher could be recorded. The researcher had a total of 1050 minutes of video and audio recording and transcribed them verbatim on the child observation forms. Two undergraduate students helped the researcher to prepare the learning environment before the activities and to take photos during the activity implementation. These students were introduced to both children and parents in the first week just before the start of the activity and they were explained why they were there.

Figure 17 Learning environment where the micro-evaluation was carried out.

The teacher was in the classroom before the activity hour and welcomed the participant parents and children together with the researcher. The activities were implemented after everyone was greeted one by one and all the children were asked about how they felt. Each activity lasted about three hours. This time period included two 5-minute breaks. Throughout the implementation process the researcher made the observations and kept field notes. The focus of the observations was on the learning objectives.

3.2.2.3 Third Iteration of the Prototyping Phase: Try-Out Study

As Nieveen and Folmer (2013) emphasize, each prototype provides the design researcher with a more robust ground and with arguments for the ultimate product s/he is working on to solve a complicated educational problem. Similarly, in this study, the findings of the micro-evaluation of the second prototype shed light on the design of the third prototype. After the findings of the micro-evaluation were screened with the design support team, the third prototype of the EDCPI was created by revising the second prototype. The try-out of the third prototype was carried out with a small sample of the target users of EDCPI to investigate its practicality and effectiveness.

3.2.2.3.1 Participants of the Try-Out Study

The try-out of the third prototype was conducted in the fall semester of the 2018-2019 academic year. The try-out study was conducted in the city where the micro-evaluation was conducted (Kastamonu). This time, however, the researcher worked with another preschool institution in the city center, which was catering to children aged 36-to-72 months. In this preschool institution, there were seven classrooms and approximately 15 children in each classroom. The participants of the try-out study were two preschool teachers (Teacher 2 and Teacher 3) working in this institution, five children in total from these teachers' classrooms and the parents of these five children. The selection of this school and teachers was based on several reasons. The researcher had previously interviewed the preschool teachers at this institution for another study to learn their thoughts about STEM education in early childhood. The preschool teachers who were the participants of this study had stated that they had been very willing to apply STEM in their classroom and that they had wanted to learn STEM in-depth within the context of research conducted with a researcher from the university. In this regard, the teachers' willingness and the support of the school administration to participate in the study motivated the researcher to work with them.

At the beginning of the process, the plan was to work with two teachers at the same time and with different child-parent groups in the classes of these teachers. More specifically, the try-out was planned to be held on Sundays in one of the classes and on Saturdays in the other. However, the researcher and the teachers had difficulty in finding a sufficient number of parents (minimum five) who would participate in the study voluntarily. The voluntary participation form was sent to 17 parents in T2's classroom, but only two parents submitted their form to the researcher. Similarly, in T3's classroom, only four parents submitted their form to the researcher. One parent reported that s/he could not attend the activities regularly. Thus, the five-voluntary parent-child groups of the two classrooms were placed together in one class, and the implementations were carried out by two different teachers in the same education environment (see Table 18). All the participant parents were female. Three of the activities were implemented by T2 and two of them were implemented by T3. However, both teachers read all five activities and attended meetings with the researcher to give feedback about the activities. T2 was thirty-eight years old and had eighteen years of professional experience with children from different age-groups ranging between 3 to 6. She held a bachelor's degree in early childhood education. She had attended various in-service trainings organized by MoNE related to drama, music, and arts education. However, she had no experience or training in STEM or engineering education. At the time of this study was conducted, T2 was working with a total of 18 children aged 5-6 years.

Table 18

Characteristics of the participants in the try-out study

Child ID	Age (month)	Child's Gender	Fathert's Job	Mother's Job	Mother's Educational Level	Father's Educational Level
C9	72	Male	Computer engineer	Primary school teacher	Bachelor's degree	Bachelor's degree
C10	73	Male	Health technician	Agricultural engineer	Bachelor's degree	Associate degree
C11	61	Female	Lawyer	Sociologist	Bachelor's degree	Bachelor's degree
C12	72	Female	Electronics Engineer	Computer technician	Associate degree	Bachelor's degree
C13	65	Male	Pediatrician	Teacher	Bachelor's degree	Bachelor's degree

T3 was thirty-two years old and had eight years of professional experience with children from diverse groups (ages 3-6). She held a bachelor's degree in the field of ECE. She had never attended any in-service training or such an academic study before the current study and had no experience in STEM. During the time this study was carried out, there were 17 children aged 5-6 years in T3's classroom.

3.2.2.3.2 Try-out of the Prototype 3

The try-out study was held on Saturdays throughout the first three weeks. However, in the fourth week, the fourth activity was carried out on Saturday and the fifth activity was carried out on Sunday. The activities were held between 13:00 and 16:00. In this way, the third prototype of the EDCPI was tried-out in a four-week process. In light of the findings of the micro-evaluation, the try-out study of the third prototype was conducted in a real preschool classroom environment. In this regard, the necessary permissions were taken from the faculty to use a suitable classroom of the kindergarten where the implementation was made at the weekends. Thus, the EDCPI was tried in a real-preschool classroom setting (see Figure 18). The materials (e.g. babydolls, trucks, puppets, puzzles) which were not related to the EDCPI activities were removed from the classroom because they could distract children's attention during the learning process. Similarly, unnecessary chairs and tables were removed from the classroom to create larger space for the activity and reduce the risk of accidents. In fact, children were highly active and mobile in the learning environment during the activities in order to explore and select materials, work on their designs and try out their designs. In addition, since the adults (teachers, researchers, parents, undergraduate students) and children were together in the classroom environment throughout the activities, prevented the environment from unnecessary materials hindered any chaoting situation. It was therefore important that the area enabled children to move safely. Two undergraduate students assisted the researcher in transporting the materials to be used in EDCPI to the classroom, organizing the classroom environment, and taking photographs during the implementations.

Figure 18 Learning environment in the try-out study.

The first and last activities of EDCPI were performed by T3, while the remaining three activities were performed by T2. Since the teachers worked in the same preschool, the children and parents also knew the other teacher who implemented the activities. The teacher who would perform that week's activity was in the classroom before the activity hour and welcomed the parents and children together with the researcher. After greeting everyone and asking children how they felt, the teacher started the activity. During the implementation, in addition to short breaks (five minutes), a half-hour break was given after the step of presenting the problem to the children (before moving to the planning step). In this way, each activity was completed in a total of five sessions lasting about three hours. As in the micro-evaluation, during this process, the researcher made the observations and kept field notes about what was happening in the classroom. Besides, in each session, the implementation process was recorded by means of audio and video recorders. Audio recorders were placed under the table of each parent-child group and the camera was placed in such a way that it could see and record all the participants. A total of approximately 900 minutes of video and audio were recorded and transcribed by the researcher by means of observation forms.

3.2.3 Phase III: Assessment Phase

The summative evaluation (assessment phase) includes a summary evaluation to gain evidence of the actual effectiveness of the exact intervention developed in the prototyping phase and to present arguments which support the decision to proceed or end the project (Nieveen & Folmer, 2013; Plomp, 2010). Therefore, in the assessment phase of the present study, the focus of the researcher was on to what extent the implementation EDCPI led to the intended objectives of this DBR (Nieveen & Folmer, 2013) and to provide recommendations for its improvement (Plomp, 2010).

After the try-out was completed, the third prototype of EDCPI was revised in the light of the findings and expert opinions, and thus, the final prototype was created. Since a try-out study was not carried out for this final prototype, this final form of the EDCPI was evaluated in terms of its expected practicality and effectiveness in the assessment phase. In this context, EDCPI was evaluated in terms of whether teachers and parents who are target users could work with it (practicality) and whether they were willing to implement it in their own teaching (relevance and sustainability) (Plomp, 2010). In addition to these criteria, EDCPI was evaluated in terms of whether the predetermined learning objectives were achieved, and what the possible contributions to the children, parents, and teachers who were the target users of the curriculum (effectiveness) were.

3.3 Data Collection Tools of the Study

DBR enables one to utilize various data collection tools by means of a variety of research techniques for evaluation of design objectives and refinement of the design process (Anderson & Shattuck, 2012). On the other hand, while DBR is performed in a learning environment, many uncontrolled variables are included in the process. Therefore, design researchers endeavor to optimize the design as far as possible and to make careful observations about how the various components work (Collins et al., 2004). Similarly, in the current DBR, triangulation strategies were used by utilizing multiple qualitative and quantitative data sources, such as interviews, child observation form, child portfolios, teacher’s and researcher’s field notes, weekly journals, and audio and video recordings. Figure 19 summarizes the data sources of the study and in which phase they were used. The triangulation of data sources provided the researcher with a holistic view of EDCPI from the perspective of teachers, parents and preschool children and its developmental process.

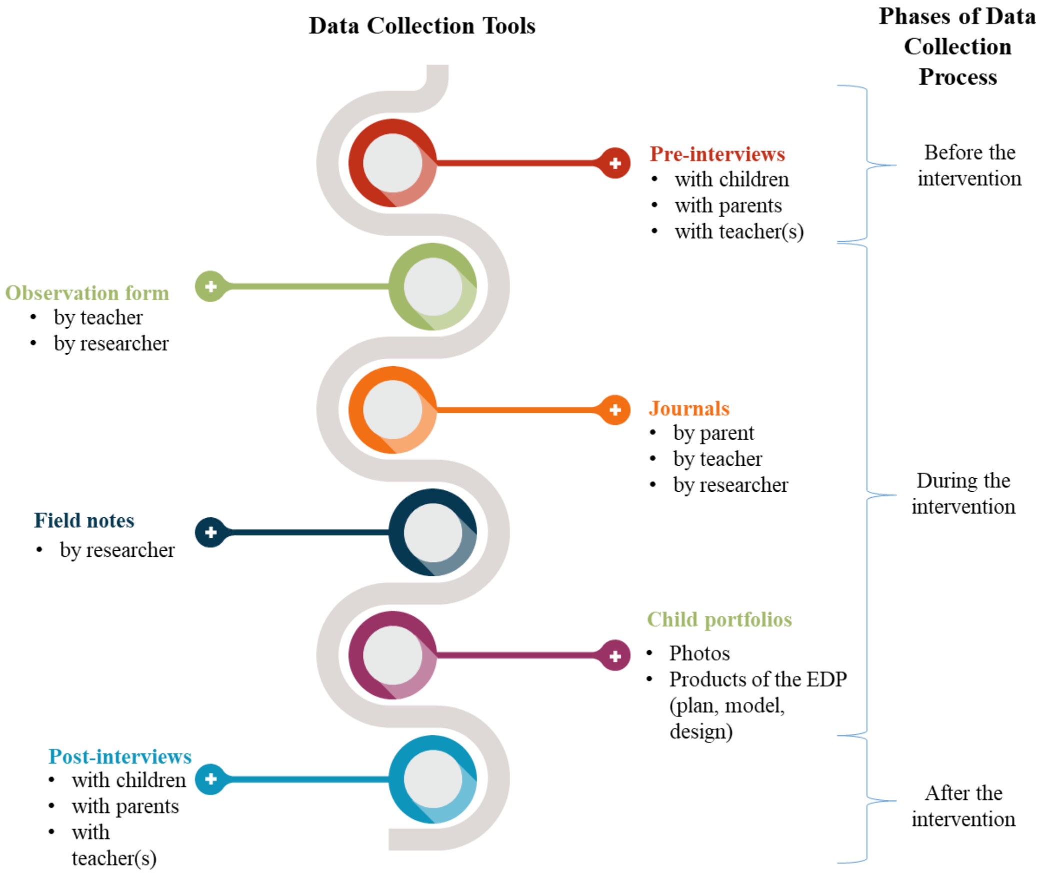

Figure 19 Data collection tools used in the study and the phases they were used.

In both the micro-evaluation and try-out study, the same data collection tools were used. However, micro-evaluation revealed some points that should be revised before the next implementation on the parent and teacher interviews and the child observation form. Therefore, before the try-out study, the required modifications were made on some of the data collection tools, and experts were consulted about these changes. The modifications conducted on the data collection tools are explained in the findings chapter. Moreover, in the try-out study, different from the micro-evaluation, journals were added among the data collection tools. Following subsections provide information about all these data sources used in the current study.

3.3.1 Teacher pre-and post-interviews

Two semi-structured interviews were conducted with preschool teachers before and after the implementation. The aim of the pre-interview was to investigate the participant teachers' up-to-date knowledge of engineering as a discipline, their initial thoughts about the place and importance of engineering in ECE, and their self-efficacy beliefs to integrate engineering into their classroom (see Appendix F). Contrary to the pre-interview, the post-interview focused on the teachers' evaluation of EDCPI in terms of its design, implementation and development process. In other words, the post-interview aimed to look at the curriculum design, development, and implementation process from the teachers' viewpoint (see Appendix I). On the other hand, some questions which focused on the teachers' views on the place and importance of engineering in the preschool period were addressed in both the interviews conducted before and after the intervention to investigate whether there were any changes in their opinions.

3.3.2 Informal interviews with teachers

In addition to pre-post interviews, in both the micro-evaluation and try-out study, the researcher met with the participant teachers by visiting their school on two days of the week throughout the implementation process (Mondays and Fridays). During these meetings, informal interviews and discussions on the activities were held with the teachers. By means of informal interviews with the participant teachers, ideas about the activity that would be held during that weekend were exchanged and the activity was rearranged accordingly. The participant teachers were visited in their schools one day a week to carry out these informal interviews. The teachers were asked to read the explanations in the activity template for the activity to be held at that weekend before coming to the meeting. These interviews were structured around a few main objectives. First, the focus of these interviews was generally on whether there were any proposed changes to the activities of the teachers, considering the characteristics of the participating children and parents in their classrooms. In this way, it was aimed to make EDCPI more appropriate for the developmental needs and characteristics of the children. Secondly, with these informal interviews it was aimed to make the activities more practical and effective by benefiting from teachers' professional experience. Hence, the teachers were asked what kinds of changes they would have made if they had prepared this activity. Finally, through these meetings and the interviews carried out at the same time, the aim was to reveal and revise any incomprehensible, unclear or confusing issues for the teacher in the activity statement. In other words, the purpose was to clarify the activity for the teacher before the implementation. All the interview sessions were recorded by using a voice recorder.

3.3.3 Parent pre-and post-interviews

EDCPI includes some learning objectives determined in the light of relevant literature not only for children but also for parents (Davis et al., 2017; Early STEM Matters, 2017; OBADER, 213; Smetana et al., 2012; Stone-MacDonald et al., 2015). The pre-post interviews conducted one week before and after the micro-evaluation and try-out studies provided the researcher with information about to what extent the parents reached the learning objectives aimed at EDCPI. In this context, the pre-interview questions focused on parents' current knowledge of engineering, their attitudes towards engineering, and their thoughts on the role of the parents in their children's engineering education (see Appendix E for the final form). The items of the "*Parents' Engineering Awareness Survey,*" developed by Yun et al. (2010), guided the researcher in preparing the interview questions. This survey consists of questions in the knowledge, attitude, and behavior dimensions, which aim to reveal parents' knowledge of engineering, their beliefs regarding the role of parents in their children's engineering education, and their attitudes towards integration of the engineering into K-12 classrooms. Some of the items included in the knowledge and attitude dimension of this scale were modified and included in the parent interviews after the expert opinion was taken.

In the post-interview, similar questions were asked with the pre-interview in order to make a comparison between the responses given prior and subsequent to the implementation. In addition to those questions, the post-interview included some questions aiming to evaluate the EDCPI and its implementation process from the parents' viewpoints. Each pre-interview with parents took about 45 minutes while each post- interview lasted approximately one hour. Since most of the participant parents worked on the weekdays and most of them had other children younger than the participant child, it was difficult to find a common time period for face-to-face interviews. For this reason, the interviews were conducted by telephone and recorded with a voice recorder with the consent of the interviewee. After the micro-evaluation, it was revealed that some interview questions in the parent pre-post interview protocols needed to be clarified. In addition, new ones needed to be added to touch on the evaluation of the EDCPI as a PI activity. Therefore, some additions and changes were made not only in the EDCPI content but also in the interview questions prior to the try-out study. The modifications made on the parent interview questions are explained in the findings chapter. The latest version of the parent post-interview can be found in Appendix H.

3.3.4 Child observation form

As aforementioned, the child observation form was developed to report observations on the extent to which the EDCPI learning objectives and indicators were displayed by the children. Expert opinion was received in the first phase of prototyping to ensure the validity of the observation form, which aims to reveal and assess children's learning in engineering with respect to skills, dispositions, and feelings. Thereby, a revised version of the observation form in accordance with the expert opinions was used in the micro-evaluation. On the other hand, both micro-evaluation and the try-out implementations revealed that observation form needed some modifications. In fact, implementations enabled the researcher to revise the child observation form. In this way, different prototypes of the observation form emerged throughout the iterations of the study (see Appendix K for its final prototype). The details of what changes were made in the observation form are clarified in the findings section.

The observation forms were independently filled out by both the teacher who implemented that week's activity and the researcher after each activity and for each of the participant children. Both the teacher and the researcher had a week to fill out the observation forms by watching the video recordings of each child. In this way, when the participant teacher attended the workshop every Saturday, she submitted the fulfilled observation forms of the activity that took place the previous week to the researcher.

In assessing children by means of observation forms, there were two main points that attention needed to be paid by the observers. First, each observed indicator needed to be explained through at least one sample behavior exhibited by the child. Secondly, the observed situation or interaction of the child with his/her parent or peers, which was believed to be a positive or negative example for the relevant indicator by the observer needed to be described in detail.

3.3.5 Child interviews

In the current study, children were interviewed one week before the implementations started and one week after they were over. The content of the interviews was based on the knowledge-related learning objectives of the EDCPI. The aim of the interviews held with children was to reveal whether children achieved the knowledge-related learning objectives of the EDCPI. In addition, post-interviews also aimed to provide data on the feelings of children about their activity experiences.

The interviews were conducted in an empty class in the children's school environment. Each child was interviewed individually, and each interview lasted about half an hour. The child interviews were audio-taped, and some field notes were taken. Both pre-and post-interview schedules were semi-structured and included some tasks and relevant questions to investigate children's current knowledge of what engineering is and what engineers do. All the child interviews were audio-taped to be analyzed by the researcher.

Within the scope of the pre-interview, each child was presented with some tasks and the interview continued with some questions to clarify the answers the child gave while performing the tasks. All the tasks were formed in parallel with the knowledge-related objectives and indicators of the EDCPI. It aimed to present children the tasks to reveal their initial knowledge and awareness of what engineering is as a profession and what engineers do. During the interview process, various visuals designed by the researcher were used to keep the attention of children on the interview questions and content. More specifically, the researcher designed some cards that included images representing people working in different professions (see Appendix B). Two of these cards had images symbolizing the engineering profession (civil engineer and mechanical engineer). Before the researcher conducted pre-interviews with children, these profession cards were examined by the design support team in terms of to what extent the drawings represented the professions. One of the experts in the team suggested adding an apron on the engineer in the card representing the mechanical engineer. The experts expressed the opinion that the other cards adequately represented the professions. Thereby, after the required modification on the card representing the mechanical engineer was conducted, the cards were used in the child pre-interviews.

At the beginning of the pre-interview, the researcher asked the child to look at the images on all the cards one by one and indicate which person or persons were the engineers on these cards. Then, the child was asked why s/he thought the person on this card was an engineer. In addition, the child was asked whether s/he had heard of the engineering profession before and what the engineers might be engaged in. In the context of the interview, it was also aimed to explore children’s current awareness of children's technology developed by engineers and used in everyday life. To this end, some cards illustrating some technologies produced by engineers from different fields and some natural objects were prepared (see Appendix D). Each card was presented individually to the child and asked for the name of the object on it. The child was asked to examine the pictures presented to him and to put the cards containing the pictures of the objects that could be designed by the engineer in the yellow box.

Another aim of the interview was to reveal the initial knowledge of children about the process used to solve engineering problems and generate innovation. For this reason, some cards containing visuals for the steps of the EDP were designed by the researcher. The researcher conducted a study at this point and examined children's picture books that were about engineering and addressed preschool children (Ata-Aktürk & Demircan, 2018). The picture book titled “Izzy Gizmo” (Jones & Ogilvie, 2017) among the reviewed children's books within the scope of the study was selected to be utilized in this study. The book was chosen because it included many steps of the EDP and pictures that could attract the preschool age group’s attention. Hence, some illustrations in the book were adapted to represent the EDP steps to the children more clearly, and thus four cards were prepared. The pictures on the cards depicted a child producing prosthetic wings for a wounded bird. In other words, the subject of the book was summarized in these four cards.

The cards representing the professions and EDP, together with the learning objectives and activities of EDCPI, were presented to the experts for expert opinion. After they were revised based on the views of the experts and the permission of the book editor and authors was taken for this revised version, the cards were used in the micro-evaluation phase. The task of these cards required the children to examine the pictures one by one and to sort the cards according to the order of events in the pictures. After ordering all the cards, the child was asked to tell what happened on the picture on each card.

The post-interview schedule included some follow-up questions to better understand the children's thoughts and experiences on learning in engineering in addition to all these abovementioned tasks. Indeed, the focus of the post-interview was to reveal whether children's knowledge of engineering and technology, and the importance of engineering in our lives had changed. The post-interview schedule prepared for the children is presented at Appendix G.

3.3.6 Child Portfolios

Children's portfolios were created by opening a file for each child on a computer, and each of these files was named after one of the participating children. Every week, the photos of the products (plans, models, and designs) created by the child and her/his parent during the EDP were added to this file by opening a separate folder. This file also included photographs and audio recordings reflecting the activity process the child experienced with her/his parent. In addition to these folders, each child had an engineering notebook to note their ideas with the help of their parent, write their measurement results, and draw their ideas. After completing each activity, the researcher also chose the photos reflecting the steps of EDP for each group and glued these photos to the child’s engineering notebook. In this way, with the help of the engineering notebooks in front of them, it was aimed for the children to remember what they did in the previous activity when they came to the class for the next activity and what steps they took to solve the problem.

In the current study, portfolios which included the child's engineering notebook and audio records and photos regarding the learning process enabled the researcher to gather shreds of evidence about the children’s learning process (Mcafee & Leong, 2012). Moreover, when these portfolios were evaluated together with the data obtained from other data sources of the study, it enabled the researcher to evaluate each child and this child's learning process holistically.

3.3.7 Field Notes

Field notes are the notes reflecting the researcher's own observations. In research conducted in the field of education, field notes often refer to the detailed notes taken by the researchers in education environment (school or classroom) (Fraenkel, Wallen, & Hyun, 2012). Indeed, in a qualitative study in which the researcher is the participant observer, detailed, accurate, and comprehensive field notes should be taken to reach successful research findings (Bogdan & Biklen, 2007). By considering this, in the current study, both descriptive and reflective field notes were used to gather data. In each phase of the EDP, the researcher observed each parent-child group and kept descriptive field notes. The descriptive notes mostly included the researcher's objective observation records about the picture of the workshop setting, participants of the study, their actions in each phase of the EDP, and the conversations among them. At that point, attention was paid to ensure that the descriptive observational notes did not include the researcher's personal interpretations and that they objectively reflected what happened in the field (Bogdan & Biklen, 2007; Yıldırım & Şimşek, 2011). The researcher recorded these notes in a notebook during the observation, and after each workshop she transferred her descriptive field notes behind the relevant visuals in the portfolio for each child, reflecting what the child did during the phases of the EDP. This allowed the field notes for each group to be kept in a more organized manner, thus facilitating the work while doing data analysis. In addition to the descriptive notes, the researcher also held reflective field notes. The researcher's reflective field notes included her thoughts that reflected the research process in a more personal way. Indeed, in the light of formal and informal interviews with the participants and her observations in the implementation process, the researcher noted her feelings, thoughts, problems, and impressions about the study. These field notes also included her thoughts about the problematic aspects of the EDCPI, its implementation process, and the data collection tools used within the study as well as her plans for correcting these problematic aspects in future try-outs (Bogdan & Biklen, 2007).

3.3.8 Journals

In addition to all these assessment tools, in the try-out study, journals were also used by taking into consideration the suggestion of an expert consulted after the micro-evaluation (see Table 8). The expert proposed to have journals written by the teacher, parents, and the researcher to reflect that week's activity and their experience. This would allow the researcher, the teacher and the parents to reflect on the activity of the week immediately after the implementation of the activity and keep record of their reflections. Thus, experiences related to the implementation process could be evaluated before they are forgotten. On the other hand, it would be more difficult for parents and teachers to reflect on the activity without a certain framework. For this reason, the researcher prepared a template to include some questions to guide teachers and parents in their reflections and to evaluate the effectiveness of the week.

As for the content of the journal questions, the questions in the teacher journal focused on the changes observed by the teacher in her/his students, on the new knowledge s/he learned/discovered during that day's activity, and on teachers' general evaluation of that day's activity. Similarly, the focus of the parent diary questions was whether the parents observed any change in the meaning of learning in their children during that day's activity, and their evaluation of that day's activity. The journal held by the researcher generally included the evaluation of the day and the views of the researcher on what the present experience meant for the overall study. These questions prepared for the parent and teacher journals were examined by an expert from the design support group and revised by the researcher in line with the expert opinion before the try-out study (see Appendix J).

At the end of each activity, the journal templates were distributed to the parents and the teacher, and they were asked to answer the questions and add any other things they wanted to report. The parent who finished writing her/his journal left the class, and the researcher waited in class until all parents and the teacher submitted their journals. After that day's activity was completed, the researcher wrote her own journal.

3.4 Procedure of the Study

In the current study, two of the implementations (micro-evaluation and try-out study) were carried out by following the same procedures (see Figure 20). Before the implementations, a meeting was held with the school administrator and participant teacher(s) to inform them about the purpose and process of the study. After this meeting, a semi-structured pre-interview was conducted with the teacher(s) (see Appendix F). The aim of this pre-interview was to determine the teacher's initial knowledge and thoughts about engineering and its place in ECE. (The details about how the teacher interview questions were prepared and the modifications conducted with the guidance of the findings obtained from the expert opinion are explained in the data collection tools section). The pre-interview was carried out in an empty classroom in the school and recorded by using an audio-recorder.

A few days after the pre-interview, another meeting with the teacher(s) was held and the teacher training was conducted. In this teacher training which took approximately one and half-hours, the teacher(s) was informed about STEM education, engineering, EDP, examples of engineering in the daily life, and the importance of engineering education in early childhood years. Besides, the role of the teacher in preschool children's engineering education was discussed with the teacher(s) (see Figure 20). At the end of the training, the questions asked by the teachers were responded by the researcher to make the content clearer for them.

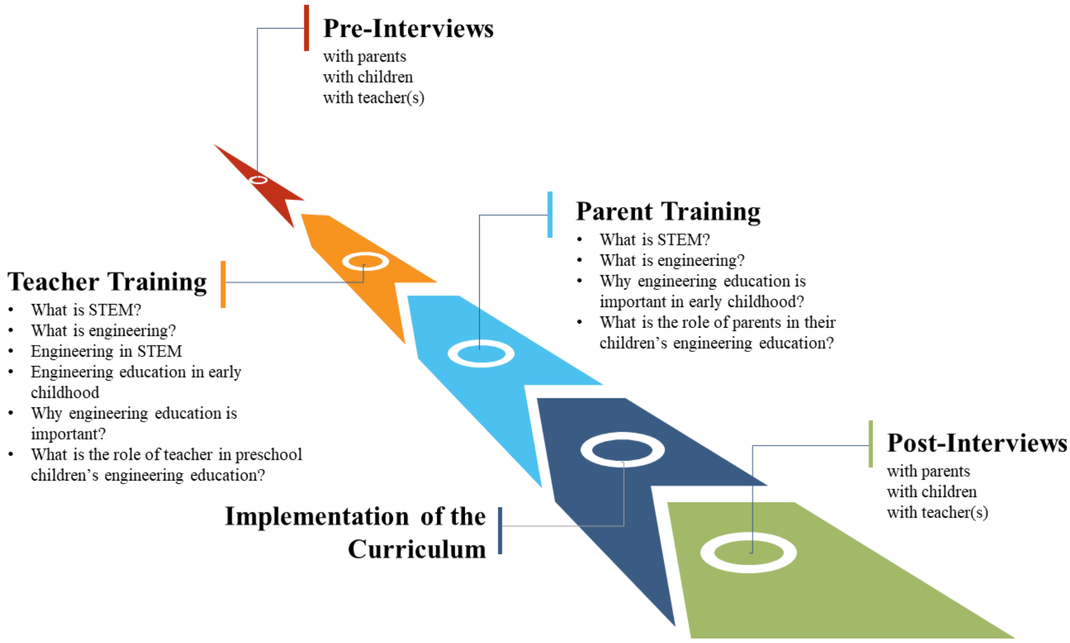

Figure 20 The procedure followed by the researcher in the micro-phases of the study (in both micro-evaluation and try-out study).

After the teacher training completed, the draft design principles and the learning objectives and indicators of EDCPI, and the template of the activity of the first workshop meeting were given to the teacher(s). The teacher(s) was asked to examine the first activity and relevant objectives and indicators by considering its suitability for her students and their parents. Besides, based on her professional experience, the teacher(s) was asked to examine the activity in terms of flow and content and to think about what changes could be made if she integrated this activity into her class as a PI activity. In this way, every week there was an exchange of ideas with the teacher(s) for that week's learning activity. This made it possible for the researcher to look at the learning activities from a more critical perspective and to produce ideas for further development of EDCPI. This cooperation in providing with the teacher(s) during the preparation of the learning activities also enabled the researcher to enhance the coherency of EDCPI with children's classroom experiences and their developmental needs and characteristics. Finally, the teacher(s) was asked to submit the parental consent forms to the parents and collect those forms back within one week from the parents who were willing to participate in the study.

A week after the last meeting, the teacher(s) and researcher came together again and the teacher's views about the first learning activity were taken by means of an informal talk. The teacher and researcher shared their opinions about the points that needed modifications to transform the learning activities into more effective and practical form by considering the needs and characteristics of the participant children and then reviewed these points. This process was repeated every week for a total of five weeks for the activity to be implemented that week. In addition, the parent consent forms submitted by the parents were examined, and the contact information of the parents who signed the forms were recorded by the researcher. In total, nine parents indicated that they wanted to participate in the study. Before the workshop started, a parent withdrew from the study because the time schedule of the workshop did not fit into her daily schedule. After the participant parents and children were determined, the researcher conducted a semi-structured pre-interview with the participant children to reveal their initial knowledge and awareness of engineering and technology. In a similar vein, the researcher got in contact with the parents and conducted a pre-interview with them to obtain their initial knowledge and thoughts about engineering in early childhood education.

After interviewing them, the researcher held a meeting with the participating parents to meet face to face and inform them about engineering education in early childhood. As in the teacher training, through the parental training carried out before the implementation of the curriculum in the micro-evaluation and try-out studies, the parents were informed about some subjects. These subjects touched also on during the parental training of two implementations were the STEM education, engineering, importance and examples of engineering to our daily life, working fields of the different branches of engineering. In addition, parents were provided with the information about the role of engineering in daily activities of their preschool children, the importance of engineering education in early childhood, and how parents could support their children's engineering education (see Figure 20). In this regard, parents were informed about what was expected from them throughout the study process (for details see 3.2.2.1.2). Different from the micro-evaluation, in the light of the obtained findings, the subject of scaffolding was also included in the parental training in the try-out study. The details about the modifications conducted on the content of the parent training were explained in the later sections.

After the completion of the pre-interviews and teacher and parent training, it was time for the implementation of the EDCPI in the classroom environment. Indeed, the EDCPI was carried out as a weekend PI workshop. This workshop was planned to be held at the faculty of education, where the researcher was working, with the participation of the teacher, the students and the parents throughout five Saturdays. During the five weekends, one of the five activities within the EDCPI was carried out at each meeting. In this regard, the implementation step of the micro-evaluation study included the implementation of the second prototype of the EDCPI within this five-week workshop with the participation of a preschool teacher, eight children in her classroom and the parents of these children. On the other hand, the implementation phase of the try-out study included the implementation of the third prototype of EDCPI in the five-week workshop with the participation of two preschool teachers, five preschool children in their classrooms, and the parents of these children. The researcher took the role of an observer during the workshop process. During this five-week implementation period, the teacher and the researcher interacted continuously by means of informal interviews to exchange their ideas and discuss their suggestions about the content, modifications, and usability for EDCPI. Therefore, the revision of the EDCPI learning activities in accordance with the teacher and other participants' needs in order to reach the most suitable engineering design curriculum for PI in ECE was possible. Indeed, this collaboration between the teacher and researcher enabled them to integrate their expertise to design, evaluate and revise the curriculum (Wang et al., 2014).

As the last step, post-interviews were conducted with all the participants a week after the workshop had been completed. Indeed, the researcher visited the teacher's class twice and interviewed the participant children. This interview schedule included some questions about the assessment of children's current engineering and technology knowledge, and some questions focused on learning about the children's experiences in the workshop process. Interviews were held with the children in an empty classroom in the school, and they were recorded with an audio recorder. After the interviews with the children were completed, the researcher interviewed the teacher(s) in order to reveal her current knowledge and thought about engineering education in early childhood and obtain her evaluation of the EDCPI design, development and implementation process. In a similar vein, as the other participants of the study, a post-interview was also conducted with the parents by means of telephone call. The post-interviews enabled the researcher to compare participants' initial and current responses to the similar questions. In brief, the data collection procedures mentioned above were followed to gain a holistic perspective about the development of the EDCPI, and to evaluate the EDCPI based on the experiences of the teacher, parents and preschool children. This data also enabled the researcher to evaluate the expected practicality and effectiveness of the EDCPI in early childhood classrooms.

3.5 Data Analysis throughout the Study

This section describes the data analysis procedures followed in all the iterations of this DBR study. As in the qualitative research, the data analysis process of this DBR had begun with the development of the first prototype (in the preliminary research phase) and continued after the data collection was completed (Creswell, 2014; Flick, 2014). In this process, data collection and analysis were maintained until a stable and robust prototype of the EDCPI was obtained, since the findings reshaped the prototypes, and the prototypes reshaped the study through the EDR cycles (Nieveen & Folmer, 2013).

3.5.1 Analysis of the Qualitative Data

In the current study, the data was collected mostly through qualitative techniques. Therefore, qualitative data analysis was utilized to produce meaning in data and to explain implicit and explicit aspects and meaning structures by classifying and interpreting verbal and visual data (Flick, 2014).

At the beginning of the data analysis process, the relevant literature was reviewed to determine the most appropriate data analysis method for this study. Indeed, the purpose was to draw the most valid deductions from the data obtained. To this end, it focused on literature related to how data can be analyzed in design-based studies and the data analysis methods were used in similar studies. This literature review revealed that there were no detailed criteria for data collection or analysis methods for DBR. Instead, the methods for collection and analysis of data were determined in the light of the specific design tasks, the problem particularly addressed in the studies, and the type of data collected (Herrington, McKenney, Reeves, & Oliver, 2007; Štemberger & Cencič, 2014). For this reason, it was possible to encounter design-based research using different data analysis methods in the literature based on their research questions and data collection tools (Gedik, 2010; Mesutoglu, 2017; Özdemir, 2016; Polat-Hopcan, 2017; Shattuck & Anderson, 2013; Wang et al, 2014). While conducting this study, the aim was to explore the EDCPI in terms of its practicality and effectiveness and investigate the aspects that needed some modifications. At the same time, the aim was to evaluate the curriculum was applied from the perspective of different participants. Therefore, the researcher used different data collection tools, such as pre-post interviews, child observation form, journals, child portfolios, and field notes. At that point, to analyze qualitative data of this study, the constant comparison method proposed by Glaser and Strauss (1965) and widely used by design-based researchers (Gravemeijer & Cobb, 2006; Özdemir, 2016; Shattuck & Anderson, 2013; Wang et al., 2014) was utilized. This method enables researchers to make comparisons between new and previously collected data, or between the new and existing codes (Shattuck & Anderson, 2013). The main reason for selecting the constant comparison method for this study was that the current DBR included a data set collected in different phases of the study, such as prior and subsequent to the implementation. The constant comparative method allowed the researcher to compare the codes and categories that emerged from these different data sets and to create new ones (Glaser & Strauss, 2006). In a similar vein, the constant comparative method, which enables researchers to compare different people's experiences of the same event by revealing differences and similarities among them (Mills, 2008), enabled the researcher to compare different participants' experiences of the same learning process.

After the data analysis method was determined, the data analysis process was initiated by transcribing interviews conducted with participants before and after the implementation. The researcher also transcribed the video and audio recordings of all the workshop sessions into a written text form (Creswell, 2014). The field notes were (taken by the researcher and teachers), and the journals (written by the parents, teachers, and the researcher) were pooled within this transcribed data. Triangulation of data by using these multiple data sources enabled the researcher to reach more valid and trustworthy data (Glesne & Peshkin, 1992). Subsequently, all the transcribed data were read to obtain a holistic viewpoint on every data source and the entire study. During this process, key issues that emerged in each data source were determined and notes were kept about them (Bazeley, 2013). In this way, the researcher became both familiarized with her data and removed the irrelevant ones. This step was followed by the transformation of the raw data into the incidents (indicators), which meant small slices of information obtained from different participants, different data sources, and the same participant over time (Creswell, 2012). The incidents obtained from one participant's data were compared with those from other participants in the same set of data to establish a foundation for the categories (Charmaz, 2006). For instance, the obtained incidents from the pre-interview data collected from a parent were compared with the incidents obtained from other parents. This enabled the researcher to compare the interview data obtained from one participant with the data obtained from other participants to reveal similar and different aspects among them. Similarly, the pre-interview data were compared with the post-interview data obtained from the same participant. This enabled the researcher to remove redundancy and provide evidence for categories (Creswell, 2012).

After searching also for incidents other than those obtained to find out the patterns in the data, the last incidents obtained from the interview data were listed in a separate folder. Besides, the data sets obtained from different data collection tools (e.g. observation form, journals, and field notes) were examined and compared with those incidents obtained from the interviews. At the next step, the categories were constructed by coding incidents into categories. First, the incidents were grouped into various codes, and then these codes were converted into more abstract categories (Creswell, 2012) (see Figure 21). When the coding was completed, the codes that had similar elements to form categories were merged (Strauss & Corbin, 1990). In this way, each incident was coded into several categories by comparing it with the existing incidents coded in this category. This coding process continued as new categories and incidents that corresponded to the existing categories emerged (Glaser & Strauss, 1965). In this way, the categories were saturated by searching for incidents that represented the category and continued the search until the unit of data could not provide the category more insight (Creswell & Poth, 2018).

On the other hand, as Holton (2010) and as many other researchers highlighted, during this coding process, the researcher can feel uncertain in the way labeling the codes is done. Indeed, how researchers define the codes is very important throughout the analysis process (Miles & Huberman, 1994). However, this feeling of uncertainty decreases as the analysis continues and by utilizing memoing (Horton, 2010). During the coding process, the researcher wrote her reflective notes in relation to what she learned from the data. Therefore, the researcher recorded memos on the margins reflecting her ideas about the emerging codes, categories, their relationships and definitions (Groenewald, 2008). In addition to contributing to the trustworthiness and credibility of the study, this enabled the researcher to explain the codes and categories in detail and to remember how she defined them (Creswell & Poth, 2018).

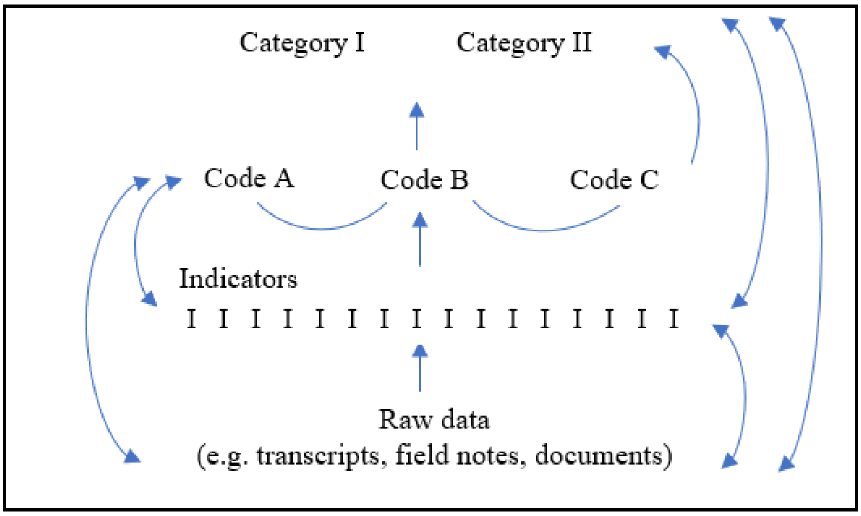

Figure 21 Constant comparison procedure followed in this study (Creswell, 2012, p. 434).

The constant comparison made among the incidents enabled the researcher to generate the theoretical properties of each category. Hence, as she continued to code, the units of constant comparative analysis transformed from the comparison of incidents into the comparison of incidents with characteristics of the categories generated from the previous comparisons of incidents (Glaser & Strauss, 1965). In a similar way, after she identified these tentative categories and their properties, she compared them with each other to reveal their similar and different aspects. At that point, she deleted or changed some of the tentative categories to obtain their final forms. On this count, the researcher discovered themes that gathered various categories under them in the light of relevant literature and her experience with the data (Glaser & Strauss, 1965). Moreover, further comparisons of the tentative categories under themes with more data enabled the researcher to improve these terms and the major category. In this way, categories based on evidences and which could be broken into smaller units of information were obtained (Willig, 2013).

Finally, the categories emerging from the data were clustered around the research question that each category was helpful to answer. At that point, a list including each research question of this study and relevant categories were prepared. In this list, some categories addressed more than one research question. After assigning all the categories to relevant research questions, the researcher examined the information about each research question and examined them in order to create a report (Hewitt-Taylor, 2001).

To sum up, the researcher saturated the categories by comparing the incidents with each other and then placing all the incidents into relevant categories (Creswell & Poth, 2018). These categories were the products of the constant comparison method. This process continued until no new category emerged. Then, each category was examined and compared with other categories that emerged in terms of their similar and different points. These categories which had similar characteristics with each other were integrated to form the sub-categories of this study (Creswell & Poth, 2018). In line with the research questions, all the categories and sub-categories collected under these categories are explained in the findings chapter.

3.5.2 Analysis of the Quantitative Data

Quantitative data were also used in the study although the aim was to score only the child observation forms, which were subjected to descriptive analysis only. As mentioned previously, the child observation form consisted of three different parts. The first part includes engineering-related skills expected to be reached by preschool children. The second part includes indicators of the thinking skills expected to be exhibited by children. Finally, the third part includes some positive and negative feelings that could be demonstrated by children during the engineering activities.

In the first part, each engineering skill corresponds to one point. For this reason, each child gets scores from this form as much as the number of skills s/he displays. The first part of the third prototype of the observation form consisted of a total of seven objectives and 39 indicators under these objectives. On the other hand, nine of these indicators were reverse items. Hence, the maximum score a child collected from the observation form was 30. Both the teacher and the researcher filled in this form, independently of each other, on a weekly basis in the light of the observations done during that week's learning activity process. For the analysis of this data, the IBM SPSS 23.0 package program was utilized, and a descriptive analysis was conducted on this program. In this context, firstly the observation forms filled out by the teacher were analyzed and the scores of each child from each activity were calculated. Then, the same procedure was performed for the observation forms filled out by the researcher. Finally, for each child, the average score given by the researcher and teacher in respect to each activity was calculated. This analysis provided the researcher with information about the average score each child received from each of the five activities of the EDCPI and thus about the development of each child in terms of engineering-related skills over the course of the curriculum implementation. The level of the child in the engineering skills was evaluated as emerging (0-10), proficient (10-20), and advanced (20-30) according to the average score of the child. Purzer and Douglas (2018) were used as a reference for the determination of the name of the levels.

The second part included indicators of a different thinking skill for each activity, and as in the first part, each indicator observed in the second part corresponded to one point. As in the skills dimension, in the dispositions dimension, the mean scores obtained from the evaluations of the teacher and the researcher were calculated to reveal the extent to which each indicator was displayed. Finally, the third part included indicators for both negative and positive feelings and these two forms based on feelings were scored independently. The evaluation in terms of feelings was aimed at revealing which feelings were displayed more and less during the implementation of the curriculum. For this reason, the frequency of the demonstration of each feeling by the children through the observation forms evaluated by the teacher and researcher for each activity was focused.

After explaining the data analysis methods used in this study, it is time to clarify the issue of how the researcher provided trustworthiness of the present study. In this respect, in the following sections, the trustworthiness of the study and the researcher's role are explained.

3.6 Trustworthiness

Every researcher should take into consideration validity and reliability issues when s/he conducts research, analyzes the results and touches on the quality of the research. Indeed, the procedures being followed to ensure the validity and reliability issues are related to the trustworthiness of the study (Denzin & Lincoln, 2017; Patton, 2002). Specifically, trustworthiness focuses on to what extent the assertions and inferences made by the researcher are justifiable and reasonable (Gravemeijer & Cobb, 2006), and it can be ensured by the researcher by taking into consideration some issues in qualitative studies (Denzin & Lincoln, 2017). These issues include credibility representing internal validity, transferability representing external validity, dependability representing reliability, and confirmability representing objectivity. How these strategies were utilized in the present study is explained below.

3.6.1 Credibility and Transferability

Credibility, representing internal validity, is one of the most essential elements in ensuring trustworthiness in qualitative research (Denzin & Lincoln, 1994). Hence, in qualitative research, it should be demonstrated that the study was credible (Creswell & Miller, 2000). As Merriam (2009) stressed, credibility is interested into what extent research findings correspond with reality. In this regard, it is possible to enhance internal validity by means of six main strategies, namely member checking, peer examination, persistent observation, triangulation by utilizing multiple data sources, theories or methods and multiple investigators. In this study, some of these strategies were employed to increase credibility.

First, the advantage of the triangulation was employed in order to accurately enhance the fidelity of the interpretations by utilizing multiple data collection methods (Glesne & Peshkin, 1992). The main idea underlying the triangulation is that more than one method is necessary to adequately describe a phenomenon and to obtain a deeper understanding of it (Pandey & Patnaik, 2014). In other words, it is based on encouraging the researcher to seek convergence among diverse and multiple information sources to structure themes and categories (Creswell & Miller, 2000). In this regard, as aforementioned, five different types of qualitative data were collected in this study: interviews, observations, field notes, child observations, and journals. Since the strength aspect of one of them compensated for the other's weak aspect, the usage of these different data sources enabled the researcher to improve both the internal validity and the reliability of the study (van den Akker et al., 2006). Triangulation was used not only in data collection but also in data analysis. The investigator triangulation was carried out by involving a second researcher in the data analysis process.

Indeed, both the researcher and another researcher from the field of ECE analyzed the interview data independently of each other and then compared their findings. In this way, these two researchers reviewed the interview data obtained from the micro-evaluation and try-out study, and codes were identified and refined by means of negotiations and discussions. Finally, specific themes were derived with mutual agreement (Patton, 2006). In addition, Creswell (2014) suggests that researchers should triangulate information sources in order to investigate the evidence they have obtained from different sources of data and utilize this evidence to establish a consistent justification for the themes. Based on Creswell's suggestion, it can be claimed that this process contributes to the validity of the research if the themes are built on the aggregation of several data sources or perspectives of the participants. In line with this, the current DBR examined the EDCPI and its implementation process from different perspectives of the participant groups (parents, children, teachers) and the themes emerged in this study based on the convergence of the data acquired from these different participants. The observers also triangulated to avoid possible biases that could arise as a single person undertakes the entire data collection process (Patton, 2002). In fact, both the teacher and researcher actively observed the implementation process, and the children were evaluated through the observation forms that were filled independently of each other.

Secondly, credibility was also increased by means of persistent and systematic observations. Persistent observation is aimed at defining the features and elements of the situation which are most related to the problem or the subject being followed and that deal with them in detail (Pandey & Patnaik, 2014). In the present study, persistent observation was carried out by observing each activity implementation process where participants' experiences, children's engineering-related learnings, and the learning setting were the focus of observation. In this way, more credible information could be obtained about all these foci points of the study. Besides, persistent observation enabled the researcher to build a relationship based on mutual trust with the participants, thus enabling the participants to be more comfortable in providing information to the researcher during the interviews (Creswel & Miller, 2000). Thirdly, member-checking was utilized to improve the credibility of the current study. As Merriam (1998, p. 204) stressed, member-checking means "taking data and tentative interpretations back to the people from whom they were derived and asking them if the results are plausible." In the current study, member-checking was utilized by consulting with parents and teachers about the accuracy of the interview data. Specifically, the data obtained from the participants were summarized at the end of each interview and the interviewee was asked whether s/he agreed with these written answers and whether there was anything else s/he would like to add (Erlandson, Harris, Skipper, & Allen, 1993).

Another criterion to ensure trustworthiness in qualitative research is *transferability,* which refers to external validity. As Merriam (1998) emphasized, external validity deals with the extent of the generalizability of the results of the research. On the other hand, qualitative research does not aim to generalize research findings. Indeed, qualitative studies deal with small samples or a sole case to comprehend the context in detail. Similarly, this design-based study may be limited in terms of generalizability to other environments because it does not guarantee the effectiveness of the designed and developed curriculum within the current study in other research environments (Collins et al., 2004). On the other hand, it was expected that thick and detailed description would contribute to making inferences concerning the transferability to other settings (Merriam 1998). Indeed, a detailed and rich description enables readers to comprehend that the study in question is credible and to make a decision on the practicality of the findings to similar settings or other contexts. Hence, in the present study, transferability to similar settings and contexts was provided by detailed describing the context, participants, implementation procedures and the design decisions (Creswell & Miller, 2000).

In addition, the content validity of the curriculum content and data collection tools were provided through expert opinions (Creswell, 2012). Moreover, the nature of this DBR necessitates an iterative cycle, and thus the evaluation of the overall process was carried out in each step of the research among the research team. Calling on expert opinions during both the design and development process of EDCPI and about data collection tools enhanced the validity of both findings and data collection tools (Kennedy-Clark, 2013). Moreover, the evaluation of the EDCPI from the perspectives of the design support team with a critical eye contributed to the credibility of the study. More specifically, the EDCPI was designed in parallel with the expert appraisal obtained in relation to its content and usability in early childhood classrooms. Lastly, validity is ensured in this DBR because of its nature of providing a concrete curriculum to be utilized in real classrooms and analyzing the usability of this curriculum in educational settings throughout the research process (van den Akker, 1999).

3.6.2 Dependability and Confirmability

Dependability, which represents the reliability, is another criterion to ensure trustworthiness in qualitative studies. Reliability refers to the stability or coherence of the research process utilized over time and is concerned with "which research findings can be replicated" (Merriam, 1998, p.205). As Eisner (1991, p.58) stressed, a good qualitative study can help us “understand a situation that would otherwise be enigmatic or confusing.” Therefore, in a qualitative study, dependability can be addressed by describing the research process in detail, and thus help future researchers in replicating the study, if not inevitably to obtain identical results. It may also enable a research design to be regarded as a “prototype model”. In addition, such detailed information enables the reader to evaluate how well the appropriate research practices are followed (Shenton, 2004). By considering all this information, in the present study, the research design, the implementation processes, and the planned and performed steps of each phase of this DBR were described in depth in the methodology and findings chapters. Furthermore, as Shenton (2004) suggests, the strategies used to ensure reliability in this qualitative research were discussed in detail. The operational specifications of data collection, the nature of the curriculum implementation processes, and the structure of the data collection tools were explained in detail. In addition to all, some other strategies were utilized to provide evidence to the reliability. For instance, all the transcribed data were checked to ensure that there were no mistakes made in the course of transcription. The researcher also constantly compared the data with the emerging codes and recorded memos concerning the codes, categories and their meaning to ensure that the definition of codes did not include any drift (Gibbs, 2007). The researcher also recorded her personal thoughts while making observations during the implementations of each activity and conducting interviews with the participants, with the aim of noting and checking responses that seemed unfamiliar to her or incorrect against later observations (researcher reflexivity) (Fraenkel, Hyun, & Wallen, 2012).

The final criterion to ensure trustworthiness in qualitative studies is *confirmability*, which corresponds to objectivity in positivist investigations. As Patton (2002, p.14) stressed, “the instrument of a research study to be the researcher”. Indeed, the researcher’s characteristics, skills, individual beliefs and experiences may be effective on his/her interpretations. Therefore, the researcher should take steps towards ensuring that the research findings are as accurate as possible by objectively basing the study on the participants' experiences and considerations, rather than the researcher's personality traits or preferences. At that point, by providing in-depth methodological and procedural information and triangulation can be used to decline the researcher’s bias (Shenton, 2004). On one hand, the researcher should try to decline her/his bias, and on the other hand, s/he should clarify the bias that s/he brings to the research. This self-reflection of the researcher leads to a clear and honest narrative that will create positive reactions in the reader. For this reason, this study also includes the researcher’s comments on how her background (e.g. gender, culture, and beliefs) can influence her interpretation of the findings (Creswell, 2014).

3.7 The Role and the Bias of the Researcher

As Denzin and Lincoln (1994) emphasized, epistemological, ontological, and methodological beliefs of a researcher, known as research paradigm, can both guide and shape his/her research. Indeed, the role and bias of the researcher are two important factors in qualitative studies because of the interpretive nature of qualitative research, which is based on researcher's experiences with the participants and the subjective inference of the data (Creswell, 2009). Hence, the role undertaken by the researcher during the research process should be explained and disclosed in detail (Patton, 2002). Similarly, in qualitative research, researchers' beliefs and their interpretations are influenced by their social, cultural and individual politics, which are reflected in the researcher's writing. For this reason, a qualitative researcher should be reflexive, that is, be conscious about and attentive to this effect on the emerging writing and be clear on this when reporting her/his study (Creswell & Poth, 2018; Patton, 2002).

In the present study, some strategies were employed to cope with such threats. For example, the participants were informed that it was a voluntary study and that they could leave the study if they wished. Besides, the school administrators, parents, teachers, and children were kept informed about the aim and details of the current research. To prevent any bias, attention was paid to maintaining the confidentiality of the participants. Indeed, as previously addressed, nicknames (C1, C2, T1, T2, P11, P12, etc.) were used for the participants throughout data analysis to eliminate biases. In addition, observer triangulation was used during the implementation process to minimize the possible bias stemming from a single person's conducting the entire data collection process (Patton, 2002). According to Bogdan and Biklen (2007), the qualitative researcher's ability to keep detailed and comprehensive field notes that reflect his or her subjectivity is another way of protecting the study against possible biases. In line with this, in the micro-evaluation and try-out of the present study, both the researcher and the participant teachers observed all the curriculum implementation processes and reflected on their observations independently of each other recorded their reflections in the observation forms and field notes.

In the present study, the researcher undertook several roles over the course of the research process. First, she provided the participant teachers with training on engineering education in early childhood. During this process, she explained the importance of engineering education for preschool children and the main principles of EDP. Thus far, the researcher undertook the role of a guide for the teachers. Then, she collaborated with the teachers in the development and implementation of a STEM-based engineering design curriculum for PI in ECE. Indeed, the researcher supported the teachers at the point where this designed and developed engineering curriculum was implemented in an educational setting where parents and children participated. She undertook the role of a participant-as-observer during the implementation of the curriculum. In other words, she was present in the learning environment in the entire implementation process (Creswell, 2012). The researcher accounted for her presence in this learning environment by informing the teachers that she was a researcher doing research on early engineering education. The researcher also informed them that she would interview them and make observations in this learning environment for her research. However, they were not informed about what the researcher was observing.

The researcher did not intervene with the learning process during the implementation of the curriculum activities, however, in the try-out study, she sometimes warned the over-interventionist parents only by showing them a red flag. Indeed, as Barab and Squire (2004) emphasize, in DBR, researchers undertake both the designer and researcher role. Therefore, design researchers cause the interactions that they make assert in addition to observe the interactions. In this DBR, as it became difficult to observe children's learning due to parental over-intervention, the researcher intervened in the process, in line with the advice of the design support team, in the way of only the parents could understand. In the education given to the parents prior to the implementation of the curriculum, they were informed about they would be warned by the researcher by showing them the red flag to make them aware of their over-intervention.

During the micro-evaluation and try-out studies, the researcher engaged in monitoring and recording the workshop sessions, taking notes related to the entire implementation processes, carrying out interviews, and collecting and analyzing research data. On the one hand, situating the research in the real setting might be considered as a threat to the trustworthiness of the research. On the other hand, this active participation enabled the researcher to interpret the research by means of the experience gained in the context of the research, to promote the design process and to solve design problems (Barab & Squire, 2004). She had visited the classes and participated in children’s daily activities with them before any workshop practice started. On this count, the children became accustomed to the researcher after a spending a few hours together. This allowed the researcher to observe the children without creating an effect on them stemming from her presence. Indeed, as long as the researcher remains in the observed environment longer, the first effect of the researcher on the observed individual will be further reduced. That is, as the number of observations and the time span increase, the observed process will return to its natural environment (Yıldırım & Şimşek, 2011). For this reason, the researcher participated in all workshop sessions and made long-term observations on the participants and the learning environment. In a similar vein, as

Yıldırım and Şimşek (2011) emphasized, it can be possible to mention such a researcher effect on the participants. Data collected in long-standing interviews are more valid because as the length of the interview progresses, an environment based on trust develops over time. Similarly, data collected through multiple interviews with the same individual is also stronger in reflecting the truth. Taking this into consideration, the researcher kept the length of interviews with the participants long. Indeed, each interview conducted with the parents and teachers lasted approximately forty-five minutes, while each interview conducted with the children lasted approximately forty minutes. She also interviewed each participant twice, once at the beginning and once at the end of the intervention.

CHAPTER 4

FINDINGS

This study mainly focused on to design and develop an effective and practical early engineering design curriculum which involves parents in the learning process and support preschoolers learning. It also focused on define essential design principles as factors that should be considered while designing and developing such a curriculum. In this regard, the first aim of the study was to develop the design of the curriculum and to identify its main characteristics. The second aim was to reveal the possible contributions of the developed curriculum to the preschool children in terms of their learnings in Science, Technology, Engineering, and Mathematics (STEM) disciplines. In addition, possible contributions of this curriculum to the parents and teachers was aimed to find out.

In accordance with these aims, the current chapter presents the findings obtained from the data analysis. Firstly, findings regarding the formative evaluation of the curriculum and of the design principles were presented with respect to the three iterations of the prototyping phase (expert appraisal, micro-evaluation, and try-out). Findings obtained from each iteration were presented respectively in the context of learning activities, learning objectives, and assessment tools. After the formative evaluation, these characteristics were structured as final design principles and both the facilitators and barriers of the STEM-based Engineering Design Curriculum for Parental Involvement in Early Childhood Education (EDCPI) were identified from the participants' point of view. In this way, the first research question of the study was about how to design and develop such a curriculum and its main characteristics. Secondly, the possible contributions of the EDCPI to the preschoolers were examined under four main dimensions (knowledge, skills, dispositions, and feelings). Thus, the second research question was addressed. Thirdly, the possible contributions of EDCPI to the parents were investigated in the light of the findings of pre-post interviews and parent journals, as an answer to the next research question. Lastly, possible contributions of the EDCPI to the teachers were brought into view and thus the last research question was addressed.

4.1 Design and Development of the Curriculum

In this section, findings regarding the necessary modifications carried out during the design of the curriculum and the design principles were examined. In the first part, the first prototype and the modifications made on it after the expert appraisal was explained. Then, in the second part, findings obtained from the micro-evaluation study and modifications conducted on the second prototype in the light of these findings were addressed. In the third part, findings of the try-out study and the modifications conducted on the third prototype of the EDCPI were examined. Finally, in the last part, the explanations related to how the final prototype of the curriculum was structured and the final design principles were presented.

Each part presents the iterative cycles of the acts of formative evaluation, analyze, and redesign of different prototypes of the EDCPI. In this context, in the following sections, respectively findings of the formative evaluation of each prototype, the findings obtained from the analysis, and the modifications performed on the prototypes are presented.

4.1.1 First Iteration: Expert Appraisal

The prototyping phase of the study started after the preliminary research phase. In the preliminary research, the main characteristics of EDCPI were determined in the light of context analysis and review of the literature. In this way, eight main characteristics were identified (see Figure 22).

Draft Design Principles

- Developmentally appropriateness
  - Clearly identified and articulated learning objectives
  - Consistency with classroom and real-world experiences
  - Appropriateness with developmental needs, interests, and characteristics
  - Flexibility and adaptability
  - Consistency with the existing curriculum
- Balance in terms of learning objectives
- Learning by discovery
- Learning by designing
- Providing preschool children with experience in STEM
- Learning experiences based on creativity and usage of daily life materials
- Learning process supported by parental involvement
- Versatile assessment process

Figure 22 Draft design principles of the EDCPI.

In addition to this draft design principles, learning objectives of the EDCPI for parents and children were determined in the light of relevant literature. Then, two experts have consulted for this draft version of EDCPI learning objectives. Experts pointed out some inconsistent objectives and pedagogically and terminologically inappropriate expressions in the learning objectives and relevant indicators. After modifying the learning objectives and indicators in line with the recommendations of these two experts, the first prototype of the learning activities and data collection tools were designed. Then, for the whole of the first prototype of EDCPI, which includes learning objectives, activities and assessment tools, the expert opinion was obtained. In the following sections, expert opinions on the first prototype of EDCPI and changes made in line with these views are presented (see Figure 23).

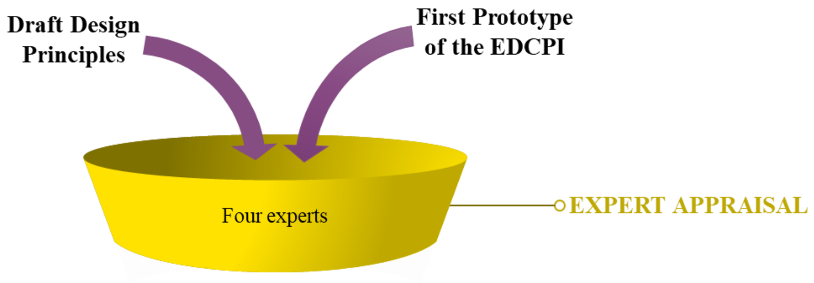

Figure 23 The first iteration of the study and the inputs of the design process.

4.1.1.1 Findings of Expert Appraisal on Learning Objectives

As abovementioned, firstly design principles and parent and child-related learning objectives of the EDCPI were specified, and two experts were consulted for the learning objectives. Table 19 summarizes the feedback obtained from these two experts regarding the learning objectives that needed to revise, and the modifications conducted after these suggestions.

One of the experts pointed out that learning objectives should be grouped under a variety of headings rather than a single title and the structure of the curriculum's learning objectives permitted such a grouping especially for knowledge and skills. Indeed, at the beginning of the study, all learning objectives for children had been organized under the main title of “engineering-related learning objectives" and had mostly focused on engineering-related knowledge and skills. By considering this suggestion, a literature review regarding the dimensions of the learning was conducted and it was identified that learning in early childhood occurred under four dimensions (knowledge, skills, dispositions, and feelings) (Bagiati, 2011; Katz, 1999). Therefore, early engineering education (EEE) and parental involvement (PI) literature were again reviewed and new objectives were determined in the dispositions and feelings dimensions. In this way, the learning objectives and relevant indicators of the curriculum were structured under four main dimensions. The same expert also pointed out that the first indicator of the third objective in the knowledge dimension might not be appropriate for children younger than six-year-olds. In other words, the distinction of the fields unless the

Table 19

Learning objectives, expert opinions, and conducted modifications

Objectives	***Indicators***	***Expert Opinion***	***Modification***
K1: Comprehends the meaning of engineering and technology	I2: Tells the relationship between engineering and technology I3: Learn how engineers work to meet the needs of themselves or other people	I2 is difficult for young children but if a simplified explanation is accepted that is fine. In I3, another term (e.g. say, show, describe, or discuss) should be used instead of the term of "learn"	I2: Tells what technology is (Cunningham, 2009). I3: Expresses that engineers are working to make human life easier and meet people's needs (McCue, 2016/2017).
K2: Recognizes the technologies used in daily life.	I2: Distinguishes whether the shown object or substance is an engineering product I3: Becomes familiar with the objects designed by engineers who imagine, design, and build.	Is any object that serves a purpose that is not project of engineering thinking? The same argument goes for the I3. Especially in 2018, almost everything in a classroom is designed by engineers, even food and water.	I2: Distinguishes natural objects from the human-made objects (Bers, 2008). I3: Expresses that engineers design almost everything in our world that serves a final purpose (Cunningham, 2009).
K3: Discovers various fields of engineering.	I2: Gives examples from daily life to the technologies produced in various engineering fields.	I know that kids in 1st and 2nd elementary can start differentiating the different fields of engineering, but not sure whether this is an expectation one can have at the PreK (although I don't know the exact age of PreK in Turkey).	I2: Gives examples to the technologies produced by engineers from different fields (Cunningham, 2009).
K4: Comprehends that everyone can be an engineer.	I1: Gives examples from different races, ethnicity, gender, and different qualifications from the engineers and the technologies they produce.	Not clear, should be clarified.	KO4: Comprehends that everyone can be an engineer or think like an engineer (Cunningham, 2009). I1: Gives examples to engineers from different genders and to technologies they produced (Hill, Corbert, & Rose, 2010). I2: Gives examples of situations in which s/he or someone around him/her thinks like and engineer and produces a solution (Smetana et al., 2012).

title of the field really matched the concept (e.g. the mechanical engineers works with machines). Indeed, this learning objective was adapted from the item “knowledge about various fields of engineering” which was one of the essential knowledges and skills proposed by Engineering is Elementary (EiE) team for engineering education of elementary children (children between 6 and 11 years old) (Cunningham, 2009, p.12; Cunningham et al., 2018). On the other hand, in Turkey, since children who do not reach the age of seven can continue their preschool education, this indicator wanted to be tested in this study. Hence, the learning objective was only modified in structural, and decided to be tried with preschool children. After this first expert appraisal, learning activities were designed in line with the draft design principles and revised learning objectives. As before mentioned, by considering the suggestion of the design support team, a total of five engineering activities have been designed for preschool children, with each activity focusing on one of the five thinking skills. In a similar vein, in the light of team’s suggestion, the role of parents, teacher, and children in the learning process was clarified for general in the curriculum to be explained in the parent and teacher training. At this stage, care was taken to ensure that activities were designed to provide children and parents with the opportunity to experience different fields of engineering. Thus, the five activities in the curriculum have been designed to experience three different engineering areas (civil, environmental, and industrial engineering). In addition to the learning activities, child observation form was designed in parallel with child-related learning objectives in skills, dispositions, and feelings dimensions. Learning objectives in the knowledge dimension were evaluated by pre-post interviews with children by utilizing some cards with technology and engineering design process (EDP)-related pictures. Pre-post-interviews were also designed for parents and teachers to reveal their knowledge and beliefs in early childhood engineering education and PI, and how their knowledge and beliefs changed. All these contents were screened by firstly design support group and then reviewed by four experts from different fields and modified after their suggestions. Expert opinions enabled the researcher to develop learning objectives and activities, hence, it was helpful to reach a more useful, consistent, and clear curriculum addressing preschool children and their parents.

Findings obtained from the second expert appraisal revealed that some of the learning objectives of the first prototype needed some changes. The proposed changes were mostly focused on the coherency among the objectives, indicators and the learning dimensions, and the clarity of the learning objectives. For instance, one of the experts suggested that in the first indicator of the first objective under the feeling dimension the expression of certainty should be changed. Moreover, according to the expert, this indicator should not be under the feelings dimension. In the light of these suggestions, this indicator was modified by removing the certainty in the expression (see Table 20). On the other hand, the objective and indicator did not include in any other dimension. Indeed, considering any profession as a career field is influenced by the attitude towards this profession (Ergun & Balcın, 2017), and the attitude is "a feeling or opinion about something" (Cambridge Dictionary). Therefore, this objective and indicator were considered as coherent with the feelings rather than other dimensions.

Table 20

Expert appraisals for the first prototype of the EDCPI and conducted modifications

Learning Dimension	***Learning Objective***	***Indicators***	***Expert Opinion***	***Modification***
Feelings	F1: The child considers engineering as a possible career (Cunningham, 2009).	• I1: When s/he wants to choose which profession when s/he grows up, s/he says that s/he will become an engineer.	• Coherency between the indicator and the dimension and incorrect statement.	• The child says that s/he can be an engineer when asked about which profession s/he wants to choose.
Skills	S6: The child utilizes her/his math related knowledge and skills (Fuson et al., 2015) to solve engineering design problems.	• I1: Having knowledge about space and two or three-dimensional shapes (NRC, 2009, p. 336).	• An operational definition requires.	• Having knowledge about space (below, above, beside). • Having knowledge about two or three-dimensional geometric shapes (e.g. "Look Mom, I combined two triangle blocks to make a rectangle roof.")

The expert from the field of mathematics suggested that the term "two or three-dimensional shapes" in the second indicator of the sixth objective under the skills dimension should be clarified by means of operational definition. This indicator was modified by making the statement more specific and adding an adapted example from Moomav (2010). Experts also emphasized that the objectives and indicators should be modified in shorter and clear expressions. In line with this suggestion, all the learning objectives and relevant indicators were reviewed and made free of unnecessary statements. Some spelling mistakes pointed out by the experts were also revised and corrected. Lastly, one of the experts emphasized that the five-weeks process might not be enough to identify dispositions. In fact, in the current study, some thinking skills were observed under the dispositions dimension. Therefore, the focus of this dimension was to observe the ways of thinking exhibited by preschool children during engineering activities. In this context, findings of the current study were interpreted by since longer observation and practice might be required to claim that ways of thinking are dispositions.

4.1.1.2 Findings of Expert Appraisal on Data Collection Tools

When it comes to the expert appraisals on the child observation form as the assessment tool of the EDCPI and on the other data collection tools of this study, experts made valuable contributions to the development of them. First, in the draft version of the EDCPI, the learning objectives under the feelings dimension had focused on positive feelings and had not included any negative feelings. On the other hand, when this draft was sent to experts for evaluation, one of the experts suggested that the observation form should include both positive and negative feelings. The expert emphasized that negative feelings would also be there during the implementation of EDCPI as part of the learning process, and that an effective curriculum should provide positive feelings rather than negative ones to the children. By considering this, some negative feelings were added to the observation form. At that point, the feelings category of the *Pre-Kindergarten Engineering Observation Protocol* developed by Bagiati and Evangelou, (2018, p. 98) guided the researcher. Thereby, three negative feelings and five relevant indicator behaviors which could be experienced by preschoolers during the engineering activities were added to the observation form (see Appendix K).

After all these modifications conducted on the observation form by considering the experts' suggestions, in the second prototype, there were seven learning objectives regarding engineering skills and 46 indicators (13 were reverse items) within these seven objectives. In this version of the observation form, there were also five learning objectives and nine indicators regarding the feelings. Besides, in the observation form, there were also three items reflecting the negative feelings that could be experienced by preschool children during the EDP and four indicators under these items. Lastly, the observation form included learning objectives related to the thinking skills. Curious thinking (the focus of the first activity) included nine objectives; persistent thinking included seven objectives (the focus of the second activity); flexible thinking (the focus of the third activity) included twelve objectives; reflective thinking included seven objectives (the focus of the fourth activity); and collaborative thinking included seven objectives (the focus of the fifth activity).

Another point touched on by the same expert was related to an example given by children during the post-interview. Indeed, the expert suggested that giving examples of the dishwashers to the technologies produced by expert female engineers could feed the stereotype that the woman belongs to the kitchen. Therefore, this example modified by picking different examples (e.g. food-pedal trash developed by Lillian Gilbreth, and reclining individual seats developed by Olive Dennis for more comfortable travel on trains.

Another expert had some suggestions related to the cards representing EDP and aiming to reveal children's knowledge about engineering and EDP before and after the implementation (see Figure 24). According to the expert, the character (Izzy Gizmo) must be changed, because this character with her glasses and messy hair can feed the stereotype of the mad scientist in the eyes of the children. On the other hand, as before mentioned, these pictures and the story was adapted from a children's book with the permission of the authors. Therefore, it might not be appropriate to modify the character. Furthermore, this book was selected to utilize in this study by the researcher due to some reasons. First, in another study, the researcher examined the picture books addressing preschool children in terms of engineering and EDP-related content (Ata-Aktürk & Demircan, 2018a). This book was one of a handful of books giving place all the steps of EDP. Besides, the visuals used were high-colored and interesting. Finally, the protagonist was a girl child, it was important to break down the prejudices that children could have in terms of gender of engineers (Ata-Aktürk & Demircan, 2018b). Therefore, after the expert appraisal, any modification was not conducted on the cards representing EDP.

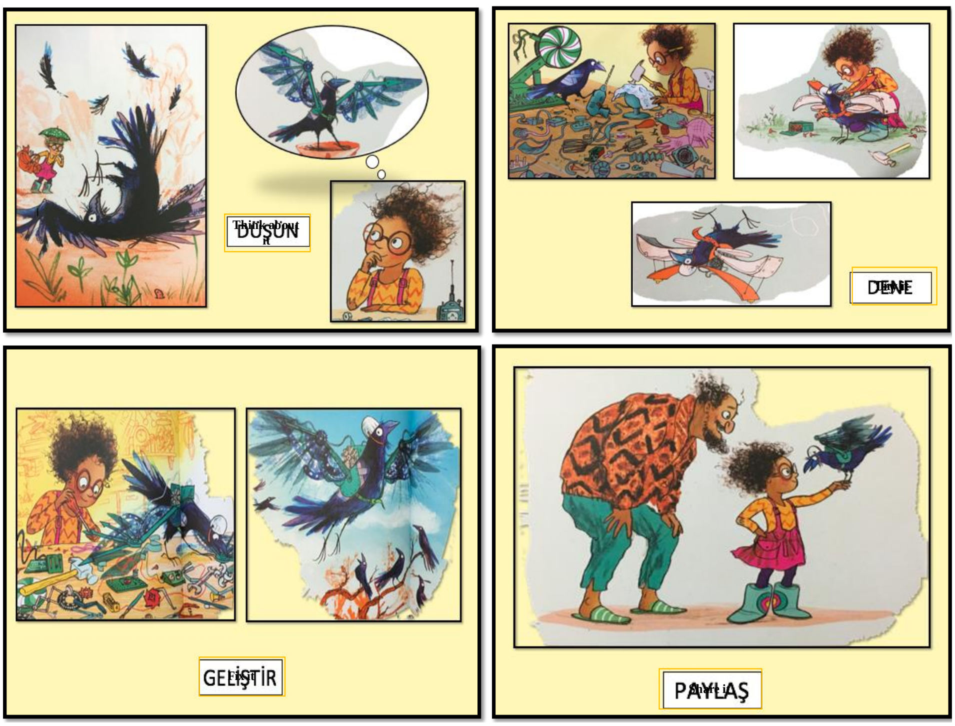

Figure 24 The first prototype of the cards representing EDP process.

Experts also provided feedback on the interview protocols. For example, one of the experts also suggested that to add probes to the interviews. Probes are defined as improvised questions that arose depending on the interviewee's answers to the interview questions (Fraenkel et al., 2012). By considering this feedback obtained from the expert, some probes which enabled the researcher to take information in more detail from the interviewee (e.g. Can you explain how EEE affect the learning in other STEM fields?; Tell me more about the PI activities you have conducted this year?; What did you disagree with your mother? Is there anything else you want to say? You said some activities were difficult for children. What makes you think that?) were added to the interview protocols (Fraenkel et al., 2012).

In addition, experts suggested to modify some interview questions. For instance, one of the experts pointed out that parents of some participant children might be the engineer, and thus, these children might have a prior knowledge or experience about engineering. With this in mind, two interview questions that reveals the extent to which children were exposed to engineering by their parents were added to the parent pre-interview (Have you ever talked to your child about engineering; Have you ever worked with your child like an engineer before?). Besides, the expert from the field of science education suggested to adding some questions to the teacher post-interview. According to her/him, these interview questions should aim at revealing the thoughts of preschool teachers about whether the EDCPI contributed to their motivation and development in the professional sense. These questions should also aim at revealing whether EDCPI contributes to teachers' attitudes to science and engineering. Hence, new research questions addressing these aims were added to the teacher post-interviews (see Appendix I). Lastly, experts reviewed the interview questions (parents, children, teacher pre-post-interviews) in terms of clarity, comprehensibility, and coherency with the learning objectives and provided feedback. In this way, the interview questions needed to modification was revised by the researcher. The researcher and a member of the design support team reviewed all these changes made.

4.1.1.3 Findings of Expert Appraisal on Learning Activities

In addition to the learning objectives and data collection tools, experts' opinion was asked for the first prototype of the learning activities. The modifications proposed by experts on the learning activities mostly focused on the age appropriateness of the activities, and the clarity, coherence, and accuracy of the content. For example, in the problem presentation part of the first activity, children are asked to give examples of the engineering products they see around them, and then they were asked to think about how our lives would be without these technologies produced by the engineers. Later, in this first prototype of the activity template, the aircraft was given as an example of technology. There was a discussion on how the plane made our lives easier and whether it would be easier or more difficult to go to a distant place if there were no aircraft. One of the experts pointed out that children may have difficulty in switching between these examples and the questions so that these parts should be given in connection with the scenario rather than an aircraft example. In line with this view, the context was structured around the "roofs", which were the main subject of activity, and engineering and how it made our lives easier was presented children in the context of the structures and their roof.

The same expert expressed concern that the scientific infrastructure of the third activity (e.g. scientific concepts such as force and motion) for preschoolers could be difficult. Indeed, this activity was designed around some physical science-related concepts such as force, motion, system and cause and effect. Children already face with these concepts in their daily lives, for example, when they go to the playground, they see these concepts in the working system of the teeter-totter or in the working system of a nutcracker. In this regard, instead of teaching the scientific background of these concepts to children, this activity aimed to give them meaningful experiences in these concepts and to lay the foundations of their future learning about these concepts. For this reason, the image representing force-load-fulcrum system was presented to make the system more clearly for teachers. Following this feedback from the expert, it was decided to observe to what extent preschool children could understand the working systems of various mechanisms and design their own systems. In this way, it was planned to decide in the light of micro-evaluation findings of whether to make changes to the third activity and what kind of changes should be made. As a modification, a warning emphasizing the main aim of the activity to the teachers was added to the activity template.

Another expert emphasized that the term open-ended materials used to describe the required materials in the activity was not clear. Taking this view into consideration, the definition of the term open-ended materials used throughout this curriculum and examples of the open-ended materials needed for each of the activity were added to the relevant activity templates. The same expert also referred to some points which could create scientific misconceptions. For example, in the first activity, the researcher used an expression that the rain and snow waters had turned into water when they were raining together. S/he emphasized that when the snow does not fall with the rain, it turns into water and this statement should be corrected. Similarly, the expert pointed out that the introduction of a tea strainer after an example of filtering the drinking water to purify the microbes in the third activity may cause children to see the tea grains as germs. In line with this, an explanation was added regarding that the filter systems could be used not only to remove germs but also to separate liquids from the solids, and large grains from small ones. The example of the tea filter and the separation of the corn grains from the flour by the filter were given after this explanation. Finally, experts drew the researcher’s attention to some wrong examples given to the concept of waste in the fourth activity. Accordingly, a definition of the concept of waste was made within the activity and the wrong examples (e.g. tea grains) were corrected (see Table 21).

Table 21

The summary of expert appraisals on learning activities

Activity requiring modification	*Expert Appraisal*	*Modification*
1st Activity	Clarity of the content	• The term "open-ended materials" was defined and exemplified.
1st Activity **4th Activity**	Accuracy of the content	• The statement which could cause some misconceptions was corrected. • An explanation was added to decrease the possibility misconceptions.
2nd Activity	Coherency of the content	• The step of helping children to understand the purpose of problem-solving was redesigned and examples and discussions about the importance of engineering for our lives were structured around the topic of bridges.
3rd Activity	Age appropriateness	• A warning was added to the activity template explaining what the main purpose of the activity was.

To sum up, after the expert appraisal, two new dimensions and relevant objectives and indicators were added to the EDCPI learning objectives. In this way, learning objectives structured around four dimensions of the learning which are knowledge, skills, dispositions, and feelings. Secondly, learning objectives and indicators were revised in the light of expert opinions in terms of their coherence with the content, and appropriateness to preschool children’s developmental levels. In a similar vein, learning activities were modified by considering the points the experts drew attention to which in terms of coherency and accuracy of the content, and appropriateness for the developmental needs and interests of preschool children. Finally, data collection tools were modified by considering the expert views on their competence of evaluating the curriculum in the perspective of the participants and the ability to assess how well the learning objectives and indicators in the curriculum were achieved. These changes made on the first prototype according to the expert opinion shaped the second prototype (see Figure 25).

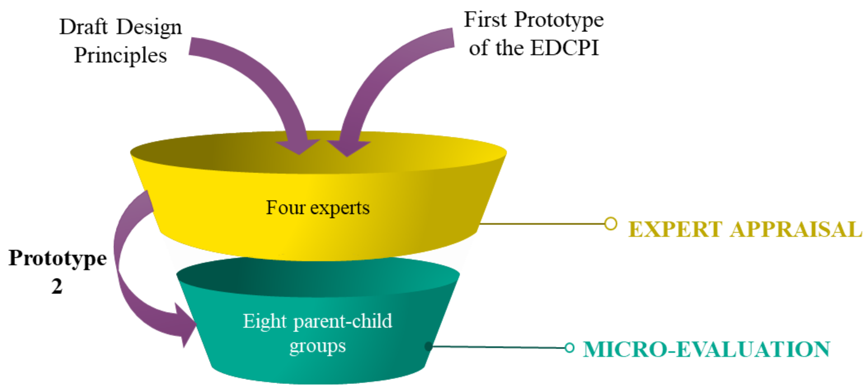

Figure 25 The first two iterations of the study and the inputs and outputs of the processes.

4.1.2 Second Iteration: Micro-evaluation Study

Micro-evaluation was conducted with a preschool teacher, eight children enrolled in this teacher's classroom and parents of these children. The participants were from a public school in Kastamonu. Findings of the micro-evaluation study were analyzed to reach an answer for the relevancy of the EDCPI to preschool children's level, its main characteristics, and its expected practicality and effectiveness. In other words, in this micro-evaluation study, EDCPI was tested in line with the participants' experience and feedback during implementation. Findings of this micro-evaluation study shed light on the revisions needed in the second prototype of the EDCPI, in terms of the learning objectives, the design principles, and implementation of the curriculum from the point of view of a group of target users.

4.1.2.1 Findings of the Micro-evaluation Study on Learning Activities

The second prototype of the EDCPI was redesigned in line with the findings obtained from the first iteration. In fact, the relevancy and consistency issues about the content of the EDCPI were handled. Hence, both EDCPI content (learning objectives, learning activities, and data collection tools) and design principles of the EDCPI were modified in the light of findings. On the other hand, the micro-evaluation study indicated that the second prototype needed some further revisions. In this section, findings regarding the learning activities and conducted modifications in accordance with these findings are presented.

- ***The First Activity: Don't Let the Parrot Get Wet***

As before mentioned, each activity within the EDCPI presents children with a different challenge to produce their own solutions for this problem by experiencing the steps of EDP. In the first activity, the engineering problem was related to the parrot's house. Indeed, there was a hole in the roof of the parrot's house and the rainwater was entering the parrot's house through this hole. In this respect, groups were expected to design and build a waterproof roof for the parrot's house. Before the activity implementation, the teacher and researcher came together to evaluate the activity. In this meeting, in general, the flow of activity was reviewed with the teacher and it was decided not to make any changes to the activity. Therefore, the activity was implemented without any changes. On the other hand, the implementation process pointed out that the activity needs some modifications. Firstly, during the introduction of the problem to the children and parents, the teacher was expected to summarize the story of "Izzy Gizmo" and explain EDP by means of the visuals representing the EDP steps. These visuals (were used also in the child interviews) were prepared by the researcher by modifying the pictures in the Izzy Gizmo in accordance to the four EDP steps adopted in this study (see Figure 24). It was planned that the visuals would be projected onto the wall in the ways that all children could see. However, the hall where the activities were conducted had some technical problems. Thus, the images were shown through a laptop. In the activity template, the story had been briefly explained. The teacher was expected to read this explanation and summarize the story during the implementation. On the other hand, it was observed during the implementation that summarizing the story made the EDP steps complicated. Since the teacher could not read the entire story before the activity, she had difficulty recalling some of the episodes while summarizing the story. This led to inconsistencies between the visuals shown and the story being told. As seen in the below quotation, the teacher focused on the size of the wings, however, in the visuals, the shape of the designed wings and usage of different materials were emphasized.

> *Gizmo thought that s/he could design a tool to wear by the bird and use comfortably. Then s/he researched, collected his materials, and asked herself/himself how I can do, how can I make it a wing to solve the bird's problem. A little wing or a larger wing? S/He tried. Firstly, s/ he made a very big wing and saw that the bird could not fly. Then, s/he thought that s/he could put it in between things like those bones. S/He then made the bird a very beautiful wing, which was not as beautiful as its own, but at least allowed the bird to fly, and allowed it to return to the old life" (T1, first activity, the step of think about it, micro*-evaluation).

The activity was revised by adding a reading time to the activity flow for being used in the try-out study. At this reading time, the teacher would read Izzy Gizmo and a discussion would be held about the steps that Gizmo follows. After the discussion, the teacher would summarize the whole story with the EDP visuals.

Secondly, in the testing step of the activity, the activity template included some sample questions that could be asked to the children by the teacher (e.g. What happened; What did you noticed; Do you want to try again; What would make this roof waterproof?). During the activity, the teacher was free to diversify these questions in order to make sense of and/or make them think about their experiences and design process experiences of children. On the other hand, the implementation process indicated that the teacher had some difficulties in this matter. The following dialogue between the teacher and one of the participant children exemplifies this inference.

T1: Why did you choose these materials (foam plates, CDs, and egg packages made from cardboard) C1?
C1: To prevent water from penetrating the roof.
T1: Well, on your first try, I noticed something. When you squeezed the water on your first roof, I guess you didn't use these ingredients (shows the plastic plates). Why did you put these on?
C1: Because this was torn (shows the cardboard).
T1: Well. First, we found our problem, then you thought about what to do, brought the materials together, then tried. When she squeezed the water, she saw that the roof was not waterproof. What did we say? We said no water. She tried, said that "I should put another waterproof material here" and put it (first activity, the step of share it, micro-evaluation).

Figure 26 One of the roof designs in the first activity.

As seen in the Figure 26, this design idea could be improved, or at least, the teacher could make the child think about what s/he could do to improve her/his design. This may be possible in the design process by guiding the child through questions that encourage the child to test her/his design, to see the lack of her/his design, to think about and produce development ideas. In addition, during an informal interview, the teacher emphasized that especially for the first weeks the detailed description of the activity in the activity template served guided her during the implementation process. For this reason, after the implementation, the activity was modified by adding more sample questions to the activity template aiming at understand the rationale underlying the child's design and to make the child more actively think while s/he testing her/his solution idea (e.g. Do you think your design did solve the parrot's problem; What do you think where the problem is; What do you can do to improve your design?; What do you plan to prevent the parrot's home being wet?). In this way, it was aimed to provide more guidance to the teacher who might have some troubles about which type of questions should be asked to guide children in EDP.

- ***The Second Activity: Can the Turtle Cross the River?***

The second activity was inviting children to help the turtle, who could not return home because of the destroyed bridge, by designing and building a new bridge. However, the bridge to be designed had to meet some limitations such as length, width, and solidity. When it comes to the findings with regards to the second activity, it was observed that during the implementation process, any connection was not established between the concept of the bridge which was the main subjects of that activity and the children's immediate surroundings. As a matter of fact, there were historical and newly built bridges in the city where the study was conducted. The activity included examples of the bridges from different parts of the world, and some questions related to their prior experience with the bridges to be asked to the children (e.g. What do you think about why the bridges were built; Anybody seen a bridge before; Who were you passing through this bridge?). On the other hand, during the implementation, these questions were not asked to the children by the teacher and therefore it became difficult to link the new learning with prior experiences and knowledge of children. The following excerpt summarizes the discussion on the bridges conducted with the children during the introduction of the problem step in the second activity. After this discussion, children drew their plans and any conversation about the bridges in the city did not carry out.

T1: Children, before you draw your plans, I want to show some bridge images to you. These images may give you an idea about how your bridges plans will look. Look, there is a bridge. What material is this bridge made of?
C1: The stone (the mother whispered in the child's ear).
C4: Made of the iron.
C7: The stone (After examining the image).
C3: Made of the brick.
T1: This bridge was made of the stone. Who do you think are going through this bridge?
C1: People.
T1: Yes, a bridge for people. Look, there are people on it. Look at this image. Is this a bridge? There is no river, no sea underneath it. Is this a bridge?
C7: Yes, there are cars under it, and people cross over.
C8: It is a pedestrian crossing.
T1: A pedestrian crossing. Is this a bridge?
C8: No.
C5: To cross the street.
T1: Yes, it serves for crossing the street.
C6: It is an overpass.

T1: Yes, it is an overpass. Is this a bridge?
Children: ...
T1: Yes, children, under the bridges of the river, sea, water does not need to pass. When we say bridge, we mean that make it easy for us to cross the street and make our lives easier, not only for people but also for cars and other vehicles (second activity, the step of think about it, micro-evaluation).

Linking between the taught content and real life to ensure meaningful learning takes place is one of the underlying design principles of EDCPI. For this reason, the teaching of new engineering-related contents should be linked to the technologies that children have previously experienced or have the chance to experience. The bridges, overpasses, and underpasses in the city where s/he lives are one of these and helps the child to think about the importance of engineering products they used in their daily life, and how engineering makes our life easier. Therefore, after the activity, the images of some of the bridges in the city were added to the activity flow to talk about it during the implementation. This might make easier for the teacher to remember the questions related to children's experiences concerning the bridges and provide children with meaningful learning by means of connections to real life. It was also thought that learnings occurred in the second activity might be supported by means of learning at home activity. Such a home-based PI activity might also be a model for the parents who wanted to support their children’s engineering education outside the school but did not know how to do. The following quotation exemplifies this need of the parents:

...I mean I'd like to support my child’s engineering education as much as I can. The teacher will lead us and say what we do. In line with what the teacher said, I will support my child as well as I can (P3, pre-interview, micro-evaluation).

Findings of the post-interviews conducted with the parents also supported this modification. As seen in the following excerpts, after the micro-evaluation study, some of the participant parents emphasized that they might not have enough time to support their children’s engineering-related learnings outside the school.

Obviously, I don't think I can support as much as I want to support. I would love to help, to play games with the kids or something, but this is just a request and I don't think I can. I'm out of town for a couple of days a week. When I'm here, I can get the kids to the park when I get back from work. Then we're coming home, kids watching TV, I'm going to my room. Sometimes we can spend some time together at the weekend. This workshop made me think it would be better to have a better time with my child (P1, post-interview, micro-evaluation).

On the other hand, EDCPI aims to provide parents with knowledge and skills how they support their children’s engineering education both in and outside the school. Although the activities implemented in the classroom within the scope of the curriculum provide examples to parents on how to support them, it was thought that it should include examples for out-of-school environments. Indeed, a simple daily life activity may be an engineering-related learning opportunity for the child. For instance, during a car trip, a child and her/his parent may talk about how the bridge they drive across can hold many vehicles. In other words, parents may support their children in developing essential skills and interest in engineering by means of conversations about engineering (Dorie & Cardella, 2014). By considering this, a sample home-based involvement activity was added to the end of the second activity. In this activity, parents and children are asked to cross a bridge in Kastamonu or another city they will visit and talk about the characteristics of this bridge. In addition, the activity includes some sample questions which were determined in accordance with the relevant literature and which can enable parents to encourage children's learning (see Appendix K).

- ***The Third Activity: Marble Carriers***

The third activity was about helping the parrot to carry three marbles to its home at the top of a tree. In this activity, as before mentioned, children were enabled to experience force-load-fulcrum concepts by launching pompoms and marbles. After the micro-evaluation studies, all participating children were given an engineering bag including open-ended materials needed for catapult construction and a manual on how to do it. In the interviews conducted after the implementation, it was concluded from the statements of both children and parents that the children were quite happy to make these catapults and to gain experience with them. In fact, as seen in the following excerpts, children had experience in various concepts (e.g. heavy and light, fast and slow) at home with the catapults they made with the materials in the kits, and they had fun.

> *My son made the catapult as soon as he came to the home. He constantly experimented with putting a marble in this catapult. He finally threw the marble and broke the chandelier (laughing) (P3, post-interview, micro-evaluation).*

> *C2: My teacher, we made the catapult with my dad.*
> *R: Really?*
> *C2: Yes. My dad kept the pieces and I glued it.*
> *R: Nice. Did you try to launch something with the catapult?*
> *C2: Yeah, the pompom launches when I release.*
> *R: Did you try anything except the pompom?*
> *C2: I tried with the marble, but it does not fly. I tried also with ping pong ball. It flew a little bit.*
> *R: Why did the ping pong ball and the pompom fly, but the marble didn't fly?*
> *C2: Because the marble is heavy (post-interview, micro-evaluation).*

Taking these findings into account, making the catapult with the child and guiding her/him through the experience with the catapult were added to the activity template as a "learning at home" activity (see Appendix K). Figure 27 presents an example from a child's EDP in the third activity.

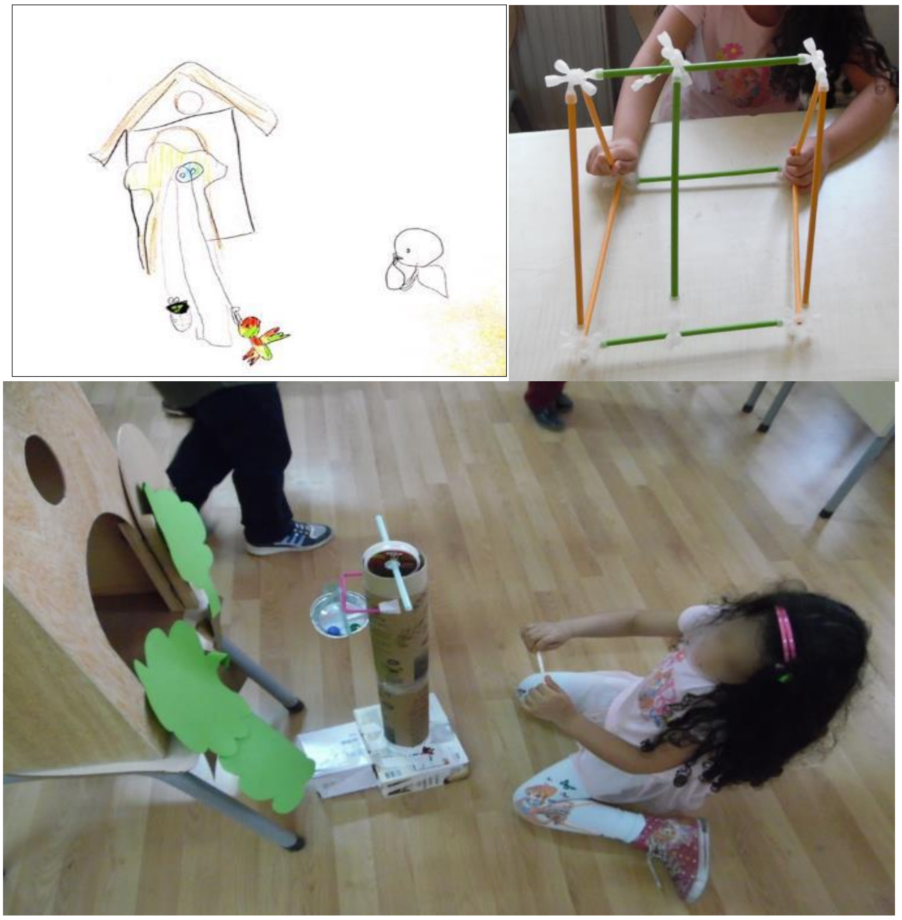

Figure 27 The plan, model, and design of a marble carrier created by one of the children.

- ***The Fourth Activity: Let's Keep the Green River Clean***

In the fourth activity, children were asked to help the animals living in the Green River. To that end, children were expected to design a tool which can clean the river from the wastes by filtering the water. Before the activity, the teacher and researcher conducted a meeting and discussed the activity. The flow of the activity was reviewed by the teacher and researcher and it was decided not to make any modification on it. Micro-evaluation findings indicated that some children had misconceptions about environmental pollution, however, they were aware that pollution had negative effects for the people and the world. Furthermore, the teacher had also some misconceptions about the concept of waste. To make this finding clear, in the following excerpt, the dialogue between a child and the teacher during the classroom discussion is presented.

T1: What do we call the engineers who solve the environmental problems?
C8: Environmental engineers.

T1: Yes, they were environmental engineers. Environmental engineers find solutions to various problems around us and thus help us. Do you have an example of the environmental problems that are bothering you in your surroundings?
C2: Because when our nature gets dirty, our world may disappear.
T1: Yes, we should find a solution to this problem.
C2: My teacher, when I came here, I was disturbed by the stones because I stumbled and fell.
T1: Yes, it can be an environmental problem. So, how does this environmental pollution influence us?
C2: There are also polar bears, it is also polluting them (fourth activity, the step of think about it, micro-evaluation).

As seen in the example above, there was a misconception that natural materials such as stone also cause environmental pollution. On the other hand, environmental pollution is among the anthropogenic changes caused by human activities such as habitat destruction, climate changes, and overexploitation. With this activity, it was aimed to draw children's attention to the impact of pollution on the degradation of the ecosystem and the depletion of certain species (NRC, 2012).

In the light of this finding, after the activity, a brief explanation that environmental pollution is a human-induced condition was included in the activity template. In addition, it was thought that adding some visuals related to environmental pollution might clarify the concept for the children. In this way, some visuals representing the air, water, and soil pollution were searched from the internet. Selected images were added to the flow of activity to be shown to children in the try-out study. In the selection of these images, the researcher paid attention to the fact that the visuals were not visually and psychologically negative. In addition, the activity was modified by adding explanations about the concepts of waste and garbage to make clear the concepts for the teacher and to explain to the children.

- ***The Fifth Activity: Let's Get the Car to the Mechanic***

In the last activity of the EDCPI, the focus was the collaborative thinking of children. Therefore, the activity was planned as a small group activity consisting of four groups in each of which two children and their parents worked together (see Figure 28). The source of inspiration for this activity was the Rube Goldberg machines. The groups were asked to design a system driven by a marble launched from the parrot's house and to bring the car to the auto mechanic through this system. Before the activity, as aforementioned, a video was shown to the groups to exemplify the chain reaction (see Appendix K for its link).

Findings related to the fifth activity indicated that children working collaboratively with another parent-child group provided children with new learnings. For instance, one of the children expressed their collaboration with another parent-child group in the following way.

C5: We tried to take the car to the repair shop on the last try. Then, we put the pipes together, then C2's dad came. In the beginning, there was his mother, then his father also came. Then we installed such a long narrow pipe. It worked.
R: Did you like the idea of his father putting a narrow pipe in there?
C5: So, maybe because the pipe was long. Maybe it made the marble stronger.
R: How did the pipe make the marble stronger?
C5: I mean… The pipe was longer. Because the pipe was longer, the marble hit from the higher. It moved faster because it was fast (post-interview, micro-evaluation) (see Figure 29).

Figure 28 Parent-child groups are working collaboratively on their designs.

In addition, some parents and the teacher stated that children gained experience in the EDP through previous activities and were working much more actively in the last activity.

…I noticed that the group activity was very nice. I mean, we observed that children experienced each step of EDP (T1, post-interview, micro-evaluation).

At the first weeks, my child did not understand what he would do. However, later, especially in the last activity, he began to put forward idea. He thought about what they could do. I mean, I think it would have been more effective if this workshop continued a little longer. Because it has *begun to get his attention, he has started to like it. Still asking when we will go to the activity (P2, post-interview, micro-evaluation).*

As in all other activities, there was an over-intervention by the parents to the design process in this activity. Therefore, no clear observation could be made for children's learning. However, considering these abovementioned findings, no change was made in the fifth learning activity for the next prototype.

Figure 29 The children and their parents are trying to get the car to the auto mechanic.

4.1.2.2 Findings of the Micro-evaluation Study on the Learning Objectives

Micro-evaluation provided the researcher with information about what extent the learning objectives were exhibited by children. In this way, it became possible to interpret to what extent learning objectives were achieved through and to make needed revisions on them. In this regard, micro-evaluations findings were investigated under the four main dimensions of learning which are knowledge, skills, dispositions, and feelings. On the other hand, it was very difficult for the teacher and the researcher to observe children and evaluate them on the observation forms due to the parents' excessive interference. In fact, as it is explained in a detailed way in the following sections, most of the participant parents in the micro-evaluation study excessively interfered in their children's learning process. Since in most of the cases parents undertook the EDP process, observation findings only reflected the interactions between the parents and their children, rather than an evaluation of children. The findings from the observation forms shed light on the development of EDCPI but provided very limited data to assess children's performance in terms of skills, dispositions, and feelings. Therefore, this section presents only findings of the micro-evaluation study about the knowledge dimension.

- ***Findings on the Knowledge-related Learning Objectives***

Interviews conducted with children before and after the intervention were used to determine the extent to which the learning objectives and indicators of the knowledge dimension were exhibited by children. In the second prototype of the EDCPI, there were five objectives and thirteen indicators under this dimension. The first learning objective was about to preschoolers' understanding of the meaning of engineering and technology. In this regard, children were expected to explain the meaning of engineering and technology and how engineers made our lives easier. Pre-interview findings revealed that none of the children, except one, recognized the engineers on the cards representing the professions while showing to themselves. According to the children the professions on the cards presented Figure 30 could be a professor, a constructor, or a repairman. To illustrate,

R: What can be this person's job?
C8: A professor who invents something.
R: What does she invent?
C8: A robot (pre-interview, micro-evaluation).

R: Let's take a look at this. What can be this man's job?
C2: He is a civil engineer.
R: How did you know he was a civil engineer
C2: I got it from his map and his dress (pre-interview, micro-evaluation).

When children were asked about what engineering was and what was the engineers' tasks, they all stated that they did not know, except for two children. On the other hand, both children had incorrect and limited knowledge about the engineering. In fact, one of these two children who had an idea about the engineering regarded engineers as constructors and stressed that engineers engaged with laying concrete and building with bricks in constructions. The other child had an engineer parent, and the findings indicated that this child's knowledge about engineering was limited to the observations that the child made when the parent was working (see Table 22). During the pre-interview, when children were asked if the engineers design the technologies on the cards shown to them, most of the children had difficulty in recognizing engineering products in daily life. In fact, one of the children thought that engineers were the constructors who design only buildings, while four of them thought that constructions such as houses and bridges designed by constructors rather than the engineers. Some children said that engineers could not design big structures like bridges and buildings, because these structures are longer than engineers. In addition, one of the children reported that engineers could design only electronic tools. According to this child, engineers had no task in the production of nonelectronic tools such as swivel chairs, medicine, and toothpaste. In a similar vein, two children reported that engineers design wheeled tools such as cars and swivel chair. In fact, almost all children thought that some technologies we used in our daily life, such as medicine, mobile phones, toothpaste, and washing machines, were designed and manufactured by the people we bought them.

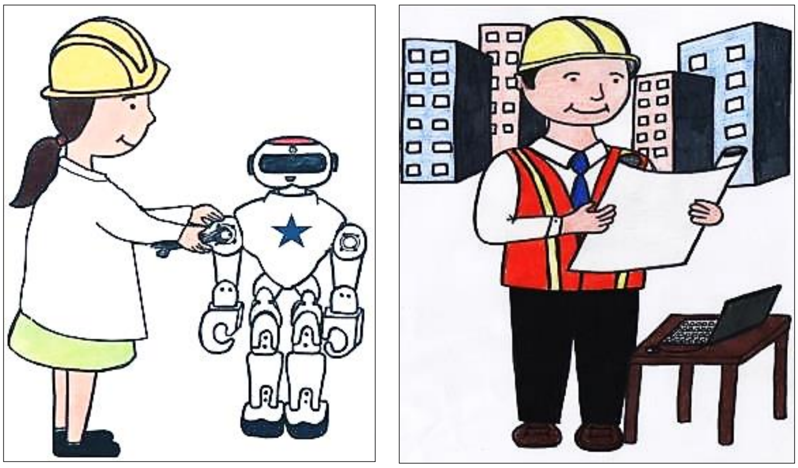

Figure 30 The profession cards representing civil engineering and mechanical engineering.

Findings of the post-interviews indicated some changes in children's perceptions of engineering. First, after the intervention, children reported that engineers created designs and make inventions. According to them, engineers create these designs to make people happy and make their life easier. In fact, findings revealed that children before the intervention who believed that engineers could not design big constructions, after the intervention, reported that civil engineers designed bridges and buildings. In a similar vein, before the intervention, the child who reported that engineers only engaged in constructions, in the post-interview, reported that engineers working in different fields had different duties such as designing computers, cellphones, and tablets (see Table 22). The findings also showed that some thoughts of children did not change after the intervention. For example, two children continued to think that engineers could design only electrical tools after the intervention. Similarly, most of the children stated that there was no role of engineers in the production of medicine and toothpaste after the intervention and that they were produced by pharmacies or doctors.

Table 22

Excerpts related to the first learning objective of the knowledge dimension

Learning Objective	***Indicators***	***Pre-interview***	***Post-interview***
K1: The child comprehends the meaning of engineering and technology	Tells what engineers do.	*R: What engineers do?* *C1: My father sometimes works on his homework. There are a lot of articles in the file, he reads the article.*	*R: Do you know what engineers do?* *C1: They construct planes.* *R: Is there anything else they do?* *C1: Yes, they do spoons, cars, buildings, and robots.* *R: Why they do all these things?* *C1: To make people happy.*
	Tells what technology is.	*R: What is the technology?* *C7: I do not know.*	*R: Do you know what technology means?* *C7: I do not know.* *R: Let's look at this classroom. Is there any technology in this classroom?* *C7: For example, television.* *R: Why do you think television might be technology?* *C7: Because it makes our lives easier.*
	Expresses that engineers are working to make human life easier and meet people's needs.	*R: Do you know what engineers do?* *C3: ...* *R: Is there any engineer you know?* *C3: No.*	*C3: Teacher, I saw the engineers made a human robot while watching the news yesterday.* *R: Really. It is good news. So, do you know what engineers do?* *C3: Yes, they made designs.* *R: Why do they make these designs?* *C3: To make people's life easier.*
		R: Do you know what engineers do? *C2: My uncle is a civil engineer. They made the constructions. They may lay concrete and lay the bricks.*	*R: Do you know what engineers do?* *C2: Each of them has different duties. For example, some of them design computers, some of them design cellphones.* *R: Hımm. What do you think engineers benefit for people?* *C2: Yes, because we can't do anything unless we do not have our stuff.* *R: Ok. Would you say something me made by engineers?* *C2: It can be stage.* *R: How a stage can make our lives easier?* *C2: It can be used in big theatres.*
	Demonstrates knowledge about the steps followed by engineers during EDP	_	*R: Let's we look at your engineering notebook. What were we doing first as engineers?* *C5: We draw it. Then we made the model by using the wooden.* *R: Yes, then?* *C5: Then we tried, but the feet of the first bridge we made were not fit. Then we achieved in our last trial.*

Note: If the child exhibits at least half of the indicators in this learning objective, it can be said that s/he achieved this learning objective.

According to the findings, most of the children were able to recognize the technologies shown to them after the intervention. Although children had difficulty in defining the technology and some of them identified technology as only electrically operated objects or objects with buttons or with various functions, most of them were aware that technology facilitates our lives. This finding pointed out that children gained an understanding of engineering and technology after the intervention. The first objective also included to being familiar with the steps of the EDP. When it comes to the EDP cards, only two children sorted the cards correctly before the intervention. This number dropped to one during the post-interview. It was thought that this finding might be related to some points on the EDP cards needed to revision. These points were discussed in the micro-evaluation findings related to the data collection tools. Findings also revealed that children demonstrated knowledge about EDP while reviewing their workshop experiences with the researcher during the post-interviews, even if they could not sort the EDP cards correctly (see Table 22).

The second learning objective was related to recognizing engineering products used in daily life. In this learning objective, children are expected to give examples of the technologies they see in their environment, to distinguish natural objects from technologies, and to express that engineering has a role in almost everything. According to the post-interview findings, four of the children could give examples of the technologies they saw in their environment or daily life, while they could not give any examples before the intervention (see Table 23). On the other hand, other four children reported that there was not any technology in their classroom or home. These children reported that they did not know what technology was. Findings also revealed that all the children, except two, distinguished natural objects on the cards shown to them from the technological tools. In fact, it was interfered from the findings that these two children considered the pinecone and tree branch as technology because they were used by people for a purpose such as making fire or preventing the landslide. In other words, these children generalized the technology to everything that works for people, and since the pinecone and tree branches are used by people for some purposes, they made this generalization for these two natural objects. To illustrate,

R: Let’s see this card.
C4: This is a tree branch.
R: Is this a technology?
C4: Yes, because there are trees to prevent the soil from slipping.
R: Do engineers design it?

C4: No, it is a tree, engineers could not design it (post-interview, micro-evaluation).
R: Is this tree branch a technology?
C6: Yes, because the branches of the tree are broken, then used to light a fire. Besides, it grows fruits when it's tree.
R: Do engineers design it?
C6: (laughing) No. It grows from seeds (post-interview, micro-evaluation).

Table 23

Excerpts related to the second learning objective of the knowledge dimension from the micro-evaluation

Learning Objective	***Indicators***	***Pre-interview***	***Post-interview***
K2: The child recognizes the engineering products used in everyday life.	Exemplifies technologies s/he sees around her/him.	*R: Let's think about the kitchen in your home. Is there any technology in your kitchen?* *C5: Sometimes my father and mother make coffee. For instance, ... I do not know.*	*R: Let's see this classroom. Is there any technology in this classroom?* *C5: (pointing to the lighting above with his finger).* *R: Is this lighting a technology?* *C5: Yes, because it works electrically.* *R: Is the technology electrically powered?* *C5: No. It could be something else.* *R: Like what?* *C5: These curtains (showing the roller blind). They are not electrically powered, but they are different from the normal curtains.*
	Distinguishes natural objects from the human-made objects.	*R: Is this tree branch a technology?* *C3: I do not know.*	*C3: This is tree branch.* *R: What do you think can it be a technology?* *C3: No, because engineers could not design it.*

Note: If the child exhibits at least half of the indicators in this learning objective, it can be said that s/he achieved this learning objective.

Another point to consider in the findings of the second learning objective was the change in children's thinking that engineers have a role in the design and production of almost everything. In fact, before the intervention, two of the children reported that engineers design almost everything. On the other hand, as can be seen in the following excerpts, this statement of the children contradicts their answers to the other questions. In other words, although these two children expressed that engineers could design everything, they didn't recognize some of the engineering products shown to them on the cards.

R: Let's look at this card.
C4: This a bridge.
R: Yes. So, do you think engineers design bridges?
C4: Yes, the engineer designs the bridge and the engineer does everything.
R: Really?
C4: Yes, everything.
R: Ok. Let's put this card on here and then look at this one.
C4: A house.
R: Yes, a house. Do you think engineers design houses?
C4: No, they do not. Constructors make houses.
R: Ok. What about this?
C4: A plane.
R: Do you think engineers design planes?
C4: No, they cannot (pre-interview, micro-evaluation).

Findings obtained from the post-interviews for this indicator revealed that after the intervention, none of the children used such an expression. In other words, after the curriculum implementation, children recognized the technologies in most of the cards shown to them and were aware of the engineers had a role in the production of these technologies. On the other hand, the findings suggest that children cannot generalize that engineers play a role in the design of everything that is man-made and makes life easier. Therefore, based on the findings of the micro-evaluation, it can be said that the indicator for expressing that almost everything which serves a final purpose in our world is designed by engineers is not provided through the second prototype of the EDCPI.

The next learning objective was based on children's discovery of different fields of engineering. In this regard, children were expected to give examples to the technologies produced by different branches of engineering and to explain how engineering is effective in diverse areas of the human world. As mentioned in the prior paragraphs, before the intervention, children had limited knowledge about engineering and had difficulty in recognizing the technologies produced by engineers. In fact, in the pre-interview, only two children had mentioned different fields of engineering (civil engineering and aircraft engineering). During the EDCPI learning activities, different areas of engineering were mentioned, and children experienced different engineering branches by producing solutions to the problems which were within the area of interest of different engineering branches.

After the intervention, they were asked whether they know any fields of engineering. Post-interview findings revealed that some children had troubles in remembering the name of different fields of engineering. In fact, some children mentioned the names that could not exist (e.g. roof engineering, toy engineering, and bridge engineering). On the other hand, two of these children gave correct examples to the technologies produced by different fields of engineering when the name of the field was reminded to them (see Table 24). In general, when the names of some areas and the technologies they produced were close (e.g. electrical engineering, mechanical engineering, and aircraft engineering), children did not have any difficulty in recognizing the technology produced in this area. However, there were still two children who confused the technologies they produced, even though the names of the areas were reminded. To illustrate,

> *…Civil engineers design important things which will serve for people. They can design chair, sofa, television, and computer (C6, post-interview, micro-evaluation).*

> *I know environmental engineering and civil engineering. Environmental engineers produce roads and medicine (C3, post-interview, micro-evaluation).*

Table 24

Excerpts related to the third learning objective of the knowledge dimension from the micro-evaluation study

Objective	***Indicators***	***Post-interview***
K3: The child discovers different fields of engineering.	Gives examples to technologies produced by engineers from different fields.	*R: What mechanical engineers do?* *C7: Robot, cellphone, and computers.* *R: Well, these phones, what do the robots do?* *C7: Because they make our lives easier.* *R: How? How do computers make our life easier?* *C7: The computers were for doing homework.*
		R: We had learned several fields of engineering. Do you remember their names? *C5: Electrical engineer, civil engineer, chemical engineer.* *R: Good. What electrical engineers do?* *C5: They work in doing the of funfairs. They work in the production of the merry-go-round and crashing cars.* *R: What chemical engineers do?* *C5: They produce medicine.* *R: So, what civil engineers do?* *C5: They build buildings like home and buildings.* *R: What mechanical engineers do?* *C5: They produce machines like the iron.*
	Explains how engineering is effective in many areas of the human world.	*C6: If the engineers weren't, living would be harder. For example, there are cargo carts, which help bring the cargoes closer.* *R: What would have happened without cargo carts?* *C6: It would have been difficult on foot.*
		R: Can I ask you something? What if the engineers weren't? *C1: People cannot live.* *R: They could live, but do you think it would be harder or easier to live?* *C1: Harder.* *R: For example, what if cars were not?* *C1: They couldn't go anywhere.*
		R: Do you think engineering benefit for people? *C3: It benefits because it makes people life easier.* *R: Would you give me an example, how they make our life easier?* *C3: Computers.* *R: They design computers and make our life easier. Ok. How the computers make our life easier?* *C3: We can do our homework on the computer. We can search the things we cannot find.*

Note: If the child exhibits at least half of the indicators in this learning objective, it can be said that s/he achieved this learning objective.

The findings also revealed that most children were aware of the importance of engineering and technology for our lives. In fact, they gave examples to different technologies and expressed what happened if these technologies were not. Although some did not give examples to technologies, they were aware of how human life would be without the technology shown to them. These findings provided evidence that the second indicator of the third learning objective has been reached by children.

The fourth learning objective in the knowledge dimension was related to comprehension of that everyone can be an engineer or think like an engineer. In this context, children were expected to give examples to the engineers from different genders and to the situations in which the child or anyone around him/her think like an engineer. Post-interview findings reflected that none of the children could give examples to the engineers from different genders and to the situations in which any person thinks like an engineer. After the intervention, two of the children thought that girls could not be an engineer. In fact, one of these children believed that girls could not know how to do something, while the other one thought that the ideas of the boys were better than girls. On the other hand, other children thought that people from both genders could be an engineer (see Table 25). These findings signified that the fourth learning objective was not reached by children through the second prototype of the EDCPI.

Table 25

Excerpts related to the fourth objective of the knowledge dimension from the micro-evaluation study

Objective	***Indicators***	***Post-interview***
K4: The child comprehends that everyone can be an engineer or think like an engineer.	Gives examples to engineers from different genders and to technologies they produced.	*R: Do you think men and women can be engineers?* *C5: Yes, they can be. For example, when a man engineer designs the robot, the woman can help him.* *R: Do you know a woman or a male engineer?* *C5: No, there is not.*
		R: Do you think men and women can be engineers? *C3: Yes, generally they can.* *R: Do you know a woman or a male engineer?* *C3: No.*
	Gives examples of situations in which s/he or someone around him/her thinks like an engineer and produces a solution.	*R: Have you or any other family member ever work like an engineer before?* *C6: No, but some of my friends want to be an engineer.*
		R: Have you or any other family member ever work like an engineer before? *C4: No, I did not see.* *R: Have you ever work like an engineer before?* *C4: No.*

Note: If the child exhibits at least half of the indicators in this learning objective, it can be said that s/he achieved this learning objective.

Finally, the fifth learning objective was related to comprehending the importance of engineering and technology to the development of society and the world. For this purpose, children were expected to tell the effects of engineering and technology on the world, make a comparison between today's conditions and old times, and to illustrate the effects of engineering and technology on the society. As before mentioned, after the intervention, children were aware that engineering and technology made our life easier. In fact, in the discussions carried out during the learning activities, most of the children were able to compare the conditions of the times when technology did not develop and the conditions today. The following excerpt from the implementation of second activity exemplifies this finding.

T1: Did people living in ancient times live in the houses built by engineers? Let's think about it.
C6: There were ancient houses.
T1: Does anyone know how they lived in the houses? Let's guess.
C6: In ruined houses made of stones.
T1: So, there may be stone houses they built with their own means. Another idea?
Children: …
T1: Can it be made of wood?
C8: There may be wooden houses.
C7: Wooden hut.
T1: Yes, they may have lived in homes like huts.
C3: Stone.
T1: They may be houses made of stone, they may have been laid on top of each other. So are the houses they live in more robust and useful, the houses you live in now more robust?
C6: Ours.
T1: Why?
C6: Because our houses are made of stone, more solid.
T1: For the sake of strength, they did not just use stones, they used other things for the sake of strength. Remember last week.
C6: It could be iron.
C4: Brick and cement.
C1: But they did not have screws.
T1: Whose screw wasn't?
C1: The old people.
T1: Yeah, they don't have screws, do they? It's a little less robust because they haven't invented the screw yet (second activity, the step of think about it, micro-evaluation).

Similarly, in the post-interviews, most of the children were able to this type of comparisons between ancient times and today’s conditions. On the other hand, the comparisons made by children were regarding the examples of the impact of engineering and technology on society rather than on the world (see Table 26). Even if they were able to compare today’s conditions with the ancient times, none of the children gave examples to the effects of engineering and technology on the world. Indeed, clarifying and illustrating these effects may require a more complex way of thinking. Therefore, it was though that, as findings from the children's responses pointed out, the first indicator of this learning objective (Explains how engineering and technology influence the world) might not be appropriate for this age group. Therefore, this indicator was removed from the learning objectives.

Table 26

Excerpts related to the fifth learning objective of the knowledge dimension from the micro-evaluation

Learning Objective	***Indicators***	***Post-interview***
K5: The child comprehends the role of engineering and technology in the development of our world and society.	Compares today's conditions with those of the past when engineering and technology were not developed.	*R: You said that cars were technology. So, what would happen if the cars weren't?* *C3: If it wasn't, we'd have to walk everywhere.* *R: So, what do you think old people were doing when there were no cars?* *C3: I do not know.* *R: I wonder what they used to go from one place to another?* *C3: Maybe they used horses.* *R: So, do you think it was easy to go from one place to the next in the past, or is it now?* *C3: Now.*
	Gives examples of how engineering and technology affect our society (positively or negatively).	*R: Do you think if there were no engineers, would we do things easier or more difficult?* *C8: More difficult. We could not wash our dresses when they get dirty. We could not wash the dishes when they get dirty. We could not take medicines when we get ill.* *R: What if there were no medicine?* *C8: When we got sick, we couldn't drink medicine and we'd get sicker.* *R: So, do you think we're more lucky than old people?* *C8: Yeah. they were also drinking linden tea to heal.*

Note: If the child exhibits at least half of the indicators in this learning objective, it can be said that s/he achieved this learning objective.

4.1.2.3 Findings of the Micro-evaluation Study on the Assessment Tools

Micro-evaluation findings had shed light on not only needed modifications in learning objectives and activities but also the ones needed for the development of assessment tools. For instance, both in pre-and post-interviews, children were asked to sequence the cards representing EDP. In this first version of the cards, the name of the EDP step represented by each card was written on the cards. The goal of this was to provide the teacher with ease during the implementation. The same cards also had been used in the pre-interviews conducted with children. However, pre-interview findings revealed that one of the children was literate and focused on the writings rather than the pictures during the interview. Therefore, before the post-interview, the cards were revised, and the writings were removed. Pre-interview findings also indicated that two of the eight participant children sequenced the cards correctly and guessed the story on the cards in the correct way. On the other hand, in the post-interview, only one child sequenced the cards correctly. Indeed, as before mentioned, during the first activity, EDP was introduced to children by means of these cards and children themselves experienced all these four EDP steps throughout the implementation of the activities. However, findings revealed that children were confused due to the pictures on the first and second cards. In the first card, Gizmo sees the bird fallen and injured, and she imagines designing a wing for the bird. In the second card, Gizmo designs a wing to help the bird to fly again. However, the pictures of the imagined wings and the designed wings were different from each other. Indeed, the imagined wings were the same with the wings designed in the second try (in the third card) rather than in the first one. As seen in the following excerpts, this difference confused some of the children.

> *The bird is fainting, and the child is thinking to invent a wing. Then she is fixing and making the bird she thought… And then, the bird is flying, then the child is disintegrating the wings, and then again fixing… The bird is turning down, and could not fly… Then the bird's wound is healed and the bird's gone. The child's father rejoiced and looked at the bird (C8, pre-interview, micro-evaluation).*

> *This card happened first because the bird is falling… Then the child is thinking about how s/he can do a favor for the bird… And then s/he is making the wings which s/he decided to make for the bird… Then the bird is flying, and then the child is making an invention. S/he is squeezing the bird's screws. Then the bird is crashing again to the floor (laughing)… Then, the bird is placing on the child's hand because the child helped it (C6, post-interview, micro-evaluation).*

When it comes to the modifications on the cards after the micro-evaluation, the first card was revised by changing the picture in the thought balloon. A picture representing the wings in the second card was added to the thought balloon instead of the previous one. Permission was granted for all these changes from authors and publishers. Figure 31 represents the prototypes of the first card before and after the modification.

Figure 31 The first EDP card (on left) and its modified version after the micro-evaluation (on right).

Another tool that required modification was the observation forms. The scoring system of the skills-related part of the observation form was prepared as similar to the scoring system of the Early Childhood Environment Rating Scale (ECERS) (Sylva et al., 2006). According to this scoring system, the teacher should assess each child by following the instruction taking place on the observation form (see Figure 32) and explain the observed behavior briefly under the relevant indicator. However, findings indicated that this prototype of the observation form was not practical for the researcher and teacher. Indeed, during an informal talk, the teacher expressed that she experienced some troubles in scoring due to the hierarchical structure of the observation form. The teacher expressed that the instruction part that would guide the scoring was somewhat complicated. After this conversation, the researcher and teacher reviewed together the observation form to make clear the instruction. However, at the following week of this conversation, the researcher observed that to score children in line with this hierarchical structure was still complicated for the teacher. This finding signified that this version of the EDCPI observation form might not be practical for target users and might require revision. Therefore, the observation form was revised by the researcher after the micro-evaluation. This modified version consisted of seven objectives related to the engineering skills and 37 indicators (including 9 reverse items) under these seven objectives. Dispositions and feelings related parts of the observation form were organized only structurally, and no changes were made on the learning objectives and indicators**.**

Micro-evaluation also revealed that some modifications should be required for also the parent and teacher interview protocols. According to the findings, there was a need for interview questions to be asked parents and teachers in order to reveal their understanding of PI in education and their current PI practices and to understand their perspectives in the evaluation of EDCPI as a PI activity. Therefore, some PI-related questions were added to the pre-interviews (see Appendix E and F). The same questions were added to the post-interview protocols to reveal whether occurred any change after the intervention in parents' and teachers' PI-related understanding and practices.

Micro-evaluation also revealed that parents' understanding of success was important to their guidance in the EDP process. In fact, some of the parents stated that they were afraid that their children would fail, so they intervened in the process. This made the researcher think that it should be revealed how parents perceive success in such an educational process. Hence, an interview question was added to the both pre-and post-interview protocols to reveal parents' understanding of success in early engineering education (What can be the indicator of success for you and your child during these activities?). After adding all these questions, expert opinions were obtained from two experts working in the field of early childhood education and necessary revisions were made on the relevant document (see Appendix E and Appendix H for the final form).

OBSERVATION FORM (Engineering Skills-Related Learning Objectives)

Name of the child:

Date:

My honorable teacher

Please evaluate each child participating in our activities by using 3 tables in the appendix. Each of these tables consists of subsections 1, 3, and 5. Please review each table for the child whose name indicated above and score by taking the following instruction into account. Please write down the relevant behavior displayed by the child below each indicator you observe.

- If you have observed any indicator in subsection **1**, the child will receive **1** point from this section.
- If you have not observed any of the indicators in subsection **1** but have observed at least half of the indicators in section **3**, the child will receive **2** points from this section.
- If you have not observed any of the indicators in subsection **1** but have observed all of the indicators in section **3**, the child will receive **3** points from this section.
- If you have observed all of the indicators listed in section **3**, but you have observed at least half of the indicators in section **5**, the child will receive **4** points from this section.
- If you have observed all of the indicators in section **5**, the child will receive **5** points from this section.
- If you have observed all of the indicators listed in section **5**, but you have observed at least half of the indicators in section **7**, the child will receive **6** points from this section.
- If you have observed all of the indicators in section **7**, the child will receive **7** points from this section.

Figure 32 The scoring system of the observation form used in the micro-evaluation study

4.1.2.4 Modifications on the Design Principles

The micro-evaluation study also provided findings on the characteristics of the EDCPI (design principles) in addition to the learning activities and assessment tools. The observations of the researcher and the post-interview with the teacher provided findings to the design principles of the study. In line with the findings obtained from the micro-evaluation study, some revisions made on some design principles, but some did not need any change. Table 27 summarizes the design principles on which any revisions were not needed to make and the rationale for this decision.

When it comes to the modifications on the design principles needed to be revised, the first revision was made on the design principle which characterized the EDCPI with PI. In fact, this design principle stressed that EDCPI relied on a learning process supported by PI. With the involvement of the parents in their children's engineering education process, it was intended to provide parents with knowledge of EEE and how to support their children's education in this field and intended to improve children's learning about engineering and STEM through the support of parents. On the other hand, findings of the micro-evaluation indicated that most of the participant parents interfered with their children's learning process and created all the design themselves rather than promoting their children's learning. Indeed, some children were very passive and had difficulty in participating in the activity due to the excessive interference of their parents. The teacher supported this finding and noted that excessive interference by some parents made it difficult for her to observe children and to assess their learning.

> *In general, they worked together, and the aim was already to work together. That is, the child was involved in the process, but parents' interference was very intense in the first weeks. Some parents were more interfering in the first weeks, but later "okay, I am the helper of my child here, I can show him the way. Let's do it together" they thought. Later, they realized that this a learning process for their children. Indeed, they realized that the parents will help there and spend time together with their child, but that this is also a process in which children will learn about engineering. But there was also a couple of parents that I observed when interfering their children throughout all the process… Due to this situation, I had some difficulties while evaluating children. For instance, most of the children drew their plans themselves, and in the observation form, there was a purpose in the form of "The child follows the plan". However, I get in a quandary about what I would write while I fulfill the observation forms. Maybe, if the process was left to the child, s/he would follow the plan" (T1, post-interview, micro-evaluation).*

Findings reflected that this interference sometimes occurred in the form of giving the child the right answer without waiting for the child to think. As a matter of fact, parents sometimes interfere in their children's material selection initiatives by telling the child which materials are appropriate rather than guiding their children to discover the materials that are

Table 27

Design principles on which no modification was conducted

Characteristics	***Design Principles***	***Rationale for not making modification***
Developmentally Appropriateness		
Clearly identified and articulated learning objectives	EDCPI should be designed as a balanced curriculum in terms of objectives under main learning areas (knowledge, skills, dispositions, feelings).	Rather than understanding the learning objectives in the observation form, the teacher experienced some difficulties in the scoring structure of the observation form. During the post-interview, she also reported that these objectives and indicators could be a guide for her in planning engineering activities to integrate STEM into her classroom. For this reason, it was inferred that the learning objectives and indicators were clear to understood and used by the teacher.
Coherency with classroom experiences and real-world	EDCPI should encourage children to be active in their education process and to explore the available materials and the answers to their questions.	The teacher expressed that the materials and the problems presented to the children already existed in the daily life of children. According to her, children already build bridges and roads for the ants, engage with solving problems during their outdoor and free play, and all these experiences were a part of their classroom and daily life experiences. Therefore, it was conjectured that the EDCPI was consistent with preschool children's classroom experiences and real life.
Appropriateness with developmental needs, interests, and characteristics	Learning activities within the EDCPI should be designed as enabling children to identify a problem, propose possible solutions, and test and improve these solution ideas.	According to the teacher the learning activities were designed in accordance with the preschool children's developmental levels and were activities which could be performed with collaborative work of children and their parents. It was observed that children lose their attention from time to time in the process of applying the activity, but it is assumed that this may be related to excessive interference by some parents and to put their children into the background and undertake the process themselves. It was also observed that the EDCPI was appropriate for parents with different demographics. In fact, in the micro-evaluation study, there were parents who work as an engineer as well as parents who was illiterate.
Flexibility and adaptability	EDCPI should be designed as a transdisciplinary curriculum that enables children all STEM disciplines under the real-life framework.	During the post-interview, the teacher stated that the contents of EDCPI were flexible in a way that would allow her to change according to the characteristics of the children in the implementation process. She expressed that this flexibility provided her to follow a different order (in the instruction part of the activities) from the one written in the plan from time to time by considering her students' interest. Besides, it was observed that EDCPI had a flexible structure suitable for making exemplifications outside the plan and taking advantage of the spontaneously occurring learning opportunities. Therefore, it was assumed that the EDCPI was flexible to make some changes on it in line with the changing characteristics of the child, families, and social environment and was appropriate to be adapted by the teachers accordingly the characteristics of their classroom.

Table 27

(continued)

Coherency with the existing curriculum	EDCPI should be based on the usage of daily life materials which motivate children to sustain engineering learning in the environments outside the school and to use their creativity.	The implementation process indicated the researcher that EDCPI provided children to develop in not only engineering-related learning objectives but also in learning objectives and indicators within the ECE curriculum. Children had the opportunity to experience learning activities which focused especially on their cognitive, motor, and socio-emotional developmental fields and included the curricular concepts taking place in the ECE curriculum. Hence, it was assumed that the EDCPI was coherent to the curriculum implemented in the Turkish preschool classrooms in terms of learning objectives and curricular concepts.
Balance in terms of learning objectives	EDCPI should allow for the evaluation of each child individually and in a versatile manner.	It was observed that learning activities within EDCPI concentrated in a balanced manner on the knowledge, skills, dispositions and feelings of children related to engineering and STEM. In this way, it was conjectured that there was a balance in the distribution of the learning objectives in four dimensions.
Learning by designing	EDCPI should be designed as a balanced curriculum in terms of objectives under main learning areas (knowledge, skills, dispositions, feelings).	It was observed that participant children and their parents experienced each step of the EDP during the activity implementation process and learning occurred in this process. Therefore, it was assumed that EDCPI provided to learn by designing.
Providing preschool children with experience in STEM	EDCPI should encourage children to be active in their education process and to explore the available materials and the answers to their questions.	During the post-interview, the teacher stated that a different area was at the forefront in each activity, but in general all these disciplines were intertwined in each EDCPI activity. The researcher also observed that children experienced a number of concepts, developed their existing knowledge and skills in other STEM skills, obtained new ones and used science and engineering terminology. Therefore, it was assumed that EDCPI was a transdisciplinary curriculum which enables the integration of different STEM fields.
Learning experiences based on creativity and usage of daily life materials	Learning activities within the EDCPI should be designed as enabling children to identify a problem, propose possible solutions, and test and improve these solution ideas.	The teacher also stressed that the learning materials used in the activities were the materials that the child could always find in his/her daily life and could produce something to himself/herself. The researcher also observed that learning activities gave the groups the opportunity to reflect their creativity to their solution ideas, plans, and designs, and children were satisfied to use open-ended materials.
Versatile assessment process	EDCPI should be designed as a transdisciplinary curriculum that enables children all STEM disciplines under the real-life framework.	Assessment tools (observation form, interviews, and questions asked children during the activities) were found to provide a versatile assessment of each child in four dimensions of learning. The activity templates were also revised by adding sample questions to enable the teacher to evaluate the child's learning. Therefore, it was assumed that EDCPI allowed the versatile assessment of children.

suitable for the limitations of the problem. Furthermore, as seen in the following dialogue, some parents whispered the correct answer in their child's ear when the teacher asked questions.

T1: Children, do you know what engineers do?
C2: Some of them build construction and some put out the fire.
T1: Maybe they can find a solution to the fire. I mean they can find a solution to prevent the fire to start.
C6: They make tablets.
T1: Yes, they make tablets. Anything else? Do they only make tablets and constructions?
C7: They make electrical things.
C3: Computer.
T1: Yes, they design computers and electrical appliances. Anything else?
C1: They make planes.
T1: Yes, they design planes.
P3: Bridge (The parent was whispering in the C3's ear).
C3: My teacher, my teacher (Asking for permission to speak.
T1: C3 tell me.
C3: Bridge.
T1: Yes, engineers design bridges (Second activity-implementation process).

Similarly, some of the parents interfered with the learning process of their children by providing the child with various improvement ideas without waiting for the child to develop ideas for the improvement of their designs. As seen in the example presented below, this situation sometimes resulted in the child crying and losing interest in the learning process.

P1: Let's we scratch light leds to the bridge.
C1: Their colors will be what I say. Let's it be pink, I like pink.
P1: Let's draw, so that the turtle will not be scared while crossing the bridge (Second activity-the step of planning).
P1: Can we connect these pipettes together?
C1: I'll do it too.
P1: We can intertwine the pipettes in such a way.
C1: Mom, let's not do in that way.
P1: How will we do it?
C1: Let's connect this (showing wooden tongue depressors). Mom, I told you not to do it. I'll do it myself (crying).
(After a while the child stopped making design and tried to build a home with the wooden tongue depressors and pipets).
P1: Please let them go, honey, we need to build a bridge. Your teacher will ask you soon, "Did you construct the bridge?" But you're not helping me (second activity, the step of try it, micro-evaluation).

Before the implementation of the activities, a one-hour parental training had been carried out with the participant parents. This training provided parents with information about what engineering and STEM are, the importance of engineering for our world and society, what is intended by EEE and its importance in early childhood, and how parents can support their children's engineering learning. On the other hand, the findings of the micro-evaluation showed that this parental training may be insufficient to achieve PI intended in the EDCPI. According to the micro-evaluation findings, there was a communication barrier between some parents and their children during the engineering activities. In fact, parents should be informed about how the adults interfere with children's learning and what could be the results of this interference. Besides, findings signified that parents should be informed about how they could contribute their children's education and development without interfering their children. The teacher and some of the parents touched on this need by the following statements.

> *First, we need to keep families in a one or two-week education. Outside of this process, parents should be educated on issues such as not interfering with the child, or respecting the child's ideas, and not performing a task instead of their child (T1, post-interview, micro-evaluation).*

> *We were also involved in such training for the first time, and we were unable to properly manage the process. So, we were more active in the activities. For example, in the last project, my son put forward more ideas. He presented his own idea in a very nice way. In others, we were generating ideas, telling the child, but the child couldn't tell properly when presenting the design. But he easily explained something that he has designed himself, he explained gladly. We might not have been too active, we could have let the child think about something, we didn't leave it to the children (P2, post-interview, micro-evaluation).*

By considering this need, to overcome the communication barrier between some parent-child couples, some modifications made on both the name and content of the relevant design principle and parental training. On the grounds that what really matters in the EDCPI is provide of the parents with scaffolding to their children's learning process, the relevant design principle has been changed to "*learning process supported by parental scaffolding*". The aim of this change was to emphasize that parents were expected to scaffold their children's learning process in the learning activities of the EDCPI which performed through the involvement of them. Indeed, in the EDCPI learning activities, children may need the support of their parents in all steps of the EDP. Therefore, in the EDCPI, parents should actively support their children's learning throughout the EDP from the introduction of the design challenge to the share of the solution with other groups. In addition, some EDCPI learning activities include homework and parents are expected to support their children by using the scaffolding method while doing their homework. In line with this design principle, the content of the parental training was also modified before the try-out study. The modifications conducted on the parental training was explained in the following subsection.

4.1.2.5 Modifications on the Parent Training

As a first step of the modification, a literature review was conducted on the scaffolding strategy. This literature review guiding the researcher in revising the content of parent training is presented in Appendix R. The reason for choosing the scaffold as a suitable strategy for this study was that the scaffolding was a method that could be applied when the child's existing knowledge and skills in any area were planned to be extended (MacNaughton & Williams, 2008). Unlike the training carried out in the micro-evaluation study, a separate title was added for scaffolding to the parental training, developed in the light of this literature review. In other words, this modified training focused on how they could use the scaffolding strategy in their children's learning processes in addition to introducing parents to how to support their children's engineering education. At that point, five components proposed by Berk and Winsler (1995) to describe features of a good scaffolding was referenced (see Figure 33).

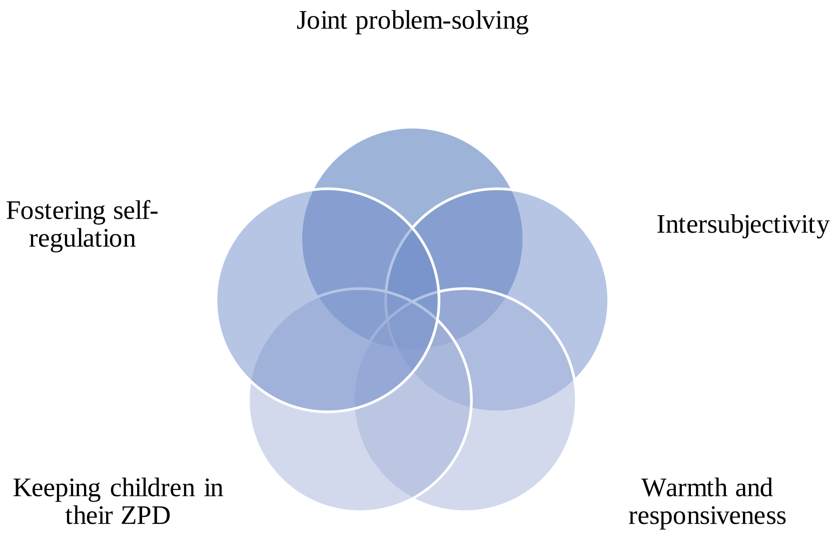

Figure 33 Components of an effective scaffolding (adapted from Berk and Winsler, 1995, pp. 27-30)

In this modified version of parental training, five components of an effective scaffolding mentioned above were introduced to parents through cases proposed by MacNaughton and Williams (2008). In order to investigate how parents would guide in the process, cases which were not directly related to engineering education process were selected. During the training each component was described by the researcher respectively, and the case related to this component was dramatized by undergraduate students (see Appendix L). In addition, parents were informed that the researcher would warn that parent by showing a red flag when any parent was very intrusive. Within the parental training conducted in the try-out study, participant parents were informed that they were expected to comply with the following rules while supporting their children's education process.

- The child should be actively engaged in the problem-solving process based on working collaboratively with an adult or peers. In this collaboration, methods such as lecturing, and modeling are not covered by the scaffolding method unless the child is actively involved in the problem-solving process. Therefore, parents should accompany the children's problem-solving adventure and allow them to find their answers, rather than giving them the right answers.
- In this collaboration process, the parent should share the same goal with the child. A correct collaboration and an effective interaction during joint activity can be achieved by working for the common goal (Berk & Winsler, 1995). Parents should remember that success is not necessarily a product, and they should have a common sense with their children about what a successful performance will look like.
- The parent should be interested in what the child is saying and what s/he does, positively comment about the child's work and involve closely to the needs of the child for additional support (MacNaughton & Williams, 2008). Parents should focus on establishing responsive and enjoyable cooperation with the child.
- Parents should be able to praise the child verbally when successful. Besides, the parent should not compare the child with another child or the child's design with another child's design.
- Parents can divide the tasks into stages that the child can accomplish. In this way, it is possible for the child to meaningfully participate in the activity as possible and concentrate on the sub-phases of the problem solving that results in productive learning through scaffolding (Belland, Glazewski, & Richardson, 2011).
- The parent should allow the child to grapple with the problems, and if the child is really stuck, s/he should intervene. On the other hand, responding continuously to the child's behavior or responding immediately ("You choose the yellow one") when dealing with an immediate problem reduces not only the child's learning but also her/his self-regulation (Berk & Winsler, 1995).
- The parent should allow the child to decide in her/his own learning process rather than manipulating the child and her/his decisions.

- Parents should gradually reduce support as the child achieves work and should receive support when the child is able to do it on his own (Berk & Winsler, 1995).

The last revision to design principles was related to the principle of learning by discovery. Indeed, EDCPI was planned as a curriculum which enables children to actively explore different characteristics of the artifacts and natural materials, new learning concepts, and the answers to their questions. In such a curriculum, children should be actively engaging in the learning process. On the other hand, the findings showed that some children were distracted and remained passive from time to time during the activities. According to the teacher, this distraction of children might be related to their lack of experience with open-ended materials. Observation data also revealed findings that would support this idea of the teacher. Indeed, it was observed that some children desired to explore some materials by dropping the activity. For instance, in the last activity, the broom pipes were included in the materials to be used by the groups in their designs. When it comes to the choosing of the materials, children took the broom pipes and they desired to extract sound from these pipes, put one end of the pipe in his/her ear and listen to the sound coming out, and extend the pipe (see Figure 34). None of the children used these pipes in their designs but spent about ten minutes exploring materials while selecting materials.

The reason for using daily life artifacts and natural materials in the EDCPI activities was the assumption that children were already familiar with these materials and that they would not have difficulty in using them in their designs. On the other hand, this finding made the teacher and researcher think that some children might had limited experience with some daily life materials used in the activities and children need to explore the materials in order to put forward an idea about different usages of these materials rather than their current usage. In other words, children had seen these materials in their daily life and were familiar with their name and usage, but they had little experience with some of them (e.g. broom pipe, pulley). Therefore, they sometimes lost their attention to the activity and were engrossed in playing with these materials. In addition, some children did not have the opportunity to explore the material, because their parents directed them to choose which materials to choose. Some parents directly told the child what material s/he should choose. Some of them even chose the needed material on their own, and the child did not even know about the chosen material and why it was chosen. The following excerpts exemplify how parents interfere with children's material selection.

Figure 34 Children are exploring the broom pipe.

P4: (after choosing the materials on his own) Come on, let's go.
C4: Dad, what are we going to do with them?

C6: Let's take the materials.
P6: I got the materials. Once we get this, okay. We will paste on this (taking a big piece of cardboard).
C6: Dad, is CD appropriate?
P6: No, it is not appropriate. It is not waterproof… Now we fill these squares with the wooden blocks and then stick them on the cardboard. So, it will be both robust and waterproof (first activity, the step of think about it, micro-evaluation).

In the micro-evaluation, groups constructed their models with the building toys (e.g. wooden blocks, construction sets). Each child was given a single type of building toys. Before designing with open-ended materials, it was thought that the prototype that would be constructed with these building toys would support children's spatial thinking and enable them to see their solution ideas into a three-dimensional form. Construction toys were chosen to be used in model making, because in the first stage, the introduction of uniform materials was thought to make it easier for children to focus their attention on modeling rather than materials. On the other hand, according to T1, children could make their models with open-ended materials instead of these building toys or children could experience these materials on their own out of the scope of the problem-solving. She expressed her ideas in the following way.

You know, in model making, we gave building toys to the children. Instead of these toys, they could make models with open-ended materials. Besides, we may let them do different things on their own, not in the form of problem solving. They like to bring things together in the classroom too. This would have been the case for the first two weeks, for example, if not always, in terms of recognizing the materials. Such an opportunity could have been offered before the activity (T1, post-interview, micro-evaluation).

T1 also stressed that another possible reason for children's distraction might be the learning environment where the micro-evaluation study was conducted. The teacher expressed her views about this issue in the following way.

> *If the environment in which we made this activity could be a little more like our classroom environment, the children might be more focused. The tables and chairs they sit on were not fit to their size. The learning environment sounded different, they were running around because there was a large and empty area, the material that was different, the ceiling was very high for them. All these factors caused their distraction (T1, post-interview).*

By considering this finding, the activity flow was modified in line with the design principle of learning by discovery. In the try-out study, a sub-step was added to the activity flow to give children the opportunity for discovering the materials and their features. In addition, by taking the teacher's suggestion into consideration, groups enabled to make their models by using open-ended materials. In this way, both in this sub-step and in model making, children could explore the materials in terms of their appropriateness to the design limitations and how they could combine them to create a solution. By means of this modification, it was aimed at providing a learning process in which children explored different characteristics of the materials before they draw their plans. In this way, it was thought that children might think about which materials they would use in their designs and reflect these materials also in their plans. In addition, since the learning environment used in micro-evaluation was not appropriate for preschool children and was a possible factor that distracted children's attention, try-out study was conducted in a kindergarten classroom. For this purpose, the necessary permissions were taken to carry out the activities at the weekends in this kindergarten.

4.1.2.6 Findings of the Micro-evaluation regarding the Facilitators of the EDCPI

Findings revealed that there were some facilitators of the EDCPI implementation process from the perspectives of the teacher and parents. According to the teacher (T1), one of the facilitators of the process was the self-confidence which developed in children due to finding a solution to a problem. T1 reflected that this self-confidence motivated children to keep on the activity. She expressed her thoughts in the following way.

> *Maybe they didn't know a lot in the field of engineering, maybe some of them only knew about it as a profession. On the other hand, during the activities, children began to think that they can be an engineer and found a solution to the problems. They said that "I solved this problem" and "I did it." This feeling occurred in children who participated actively. They were very happy during the testing. So, I heart something like that "look, I did it, I took the car to the garage" or "look I was able to carry marbles to the parrot's nest." This feeling was very good for their self-confidence and motivated children during the process (T1, post-interview, micro-evaluation).*

According to T1, another facilitator of the process was the motivation stemming from the professional development she felt. In fact, T1 stated that she felts some concerns in the first weeks; because engineering was new content for her and she would apply a curriculum was not prepared by herself. However, she reported that these concerns disappeared over time and seeing the contribution to her professional development of the process motivated her and facilitated implementation. She expressed herself in the following way.

> *During the first two weeks of implementation, I had a plan that I didn't prepare and an area I wasn't familiar with. You know, we made a preliminary preparation, you told me about STEM here, you told me about engineering, you told me what to do, but we always say that when we apply, we see some things more, we see what we need to do. But in the other weeks, this process involved me, and thoughts such as, "Oh, this is the case" or "I can tell this to children in such a way." Although I have different responsibilities, I have fondly participated in this process. Because I've seen myself improve, I've been informed, I've seen children become enthusiastic, and frankly, it motivated me and facilitated the process.*

When looked from the parents' perspective, the visuals (e.g. representing the EDP steps and the bridges in different countries of the world) presented to children during the introduction of the problems was a facilitator of the EDCPI. Due to some technical problems in the learning environment where the micro-evaluation activities were conducted, the visuals were demonstrated to the groups by means of the scene of a computer. As also seen in the below excerpts, parents emphasized that the use of these images facilitated the learning process but could be more effective if presented via a smart board or projection.

> *The visuals drew children's attention, but could it be a demonstration with a projection or a smart board (P8, post-interview, micro-evaluation).*

> *The visuals may be demonstrated by means of not on a computer screen, maybe on a larger screen or something. The kids couldn't see the pictures very closely, so it could be better on the big screen or something (P6, post-interview, micro-evaluation).*

In brief, findings obtained from the parent and teacher post-interviews drew attention to two aspects of the EDCPI. One of these aspects was the feeling of self-confidence which developed in children during the learning process and the other one was visuals used to clarify some concepts. As well as facilitators of the process, there were also some barriers. Findings regarding the factors that barrier to EDCPI are presented in the following section.

4.1.2.7 Findings of the Micro-evaluation regarding the Barriers of the EDCPI

Findings also provided the researcher with information about some barriers of the EDCPI according to the perspectives of the parents and the teachers. According to these findings, the most important barrier to EDCPI was parents' excessive interference to the process. In fact, both parents and the teacher stressed that parents should remain in the background and guide their children in order to make the learning process more effective. Below are statements from parents that illustrate this finding.

> *To me, parents were a little more intrusive. It seemed to me that we were doing the designs and the child was watching…It was like a competition program, as if parents were racing (P1, post-interview, micro-evaluation)*

> *So, I think we need to be a little more in the background. We abandoned ourselves to the activity a little too much, and I guess we thought that children could not do. Although their designs are not successful, the process can be left at least a bit more to children (P2, post-interview, micro-evaluation).*

As stated in the previous section, the observation data also provided evidence for some parents' excessive interference. Moreover, observations revealed that some children whose parents were more intrusive were reluctant and had low self-confidence during the activities process. To illustrate,

> *P3: What are you doing?*
> *C3: That is what I do (making a construction with plug-in toys).*
> *P3: But that (showing the construction what the child is building) can't be the top of our bridge.*
> *C3: Oh mom, I'm doing something.*
> *P3: We're building a bridge here; the turtle will be upset.*
> *C3: I don't know. This is your job, not my job (second activity, try it phase, micro-evaluation).*

> *He made the measurement together with the mother in the construction of the bridge and read the numbers himself. He often used numbers for measurement, and he liked it very much. During the construction of the model, the mother was more effective. Mother chose the materials and they constructed the design together. Although he did the experiments himself, he was distracted and the mother was more prominent (T1, second-activity, observation form, micro-evaluation).*

When it comes to the reasons for parents' excessive interference, some codes emerged from the post-interview data obtained from the parents. These codes were the difficulty of the activities, distraction of the children, hurriedness of the parents, and children's giving up under the difficulties. As a matter of fact, some of the parents stated that the activities were difficult for children and that this caused parents to intervene in the process.

> *Activities were difficult for the child. In some, we even had difficulty… Indeed, we had difficulty in the elevator activity (third activity). I didn't think what to design. But the other activities were such that the child could understand (P2, post-interview, micro-evaluation).*

> *The activities seemed a little difficult for the kids. We did not think that our children could do it. I mean, both me and other parents thought like that, so we thought we'd do it... My child had some troubles in putting their ideas into practice. She already drew the plan herself, and I was almost never interfered in creating the model, she did it as she wanted. She experienced difficulties in putting her plan into practice. She was choosing irrelevant materials, she took a broom pipe and tried to make sounds from it. She took silvery things and played with them (P1, post-interview, micro-evaluation).*

These were not the child could achieve alone. Children were only in the aesthetic part of the work. Because they gave importance to visuality, they contributed aesthetically… Most of our works were my ideas. Since he doesn't know what the pulley, leverage, and maneuver are, all of these are stranger for him. These are the things he's never seen before in his life. Maybe he saw a crane system as he passed a construction site. That is, he has not seen a system of catapults or reels. He observed and was more interested in the aesthetic aspect. But, of course, after he did the design, he got a better understanding of the function of the pulley system (P4, post-interview, micro-evaluation).

While some parents thought that learning activities were difficult for their children to achieve, the teacher stated that whether the activity was difficult or not was related to what was expected of children. As seen in the following excerpt, the teacher expressed that parents tended to design more complex systems, but if they gave permission, the children would be able to solve the problems proposed by them in their own way.

They did not allow their children. I know this from my child. I say to my son, "Do something like this" because that's what he should do to according to me. But I see that maybe it's not as professional as I said, but that kid has solved the problem. If the parent had allowed the child, there could be more original things. They would see that their children could achieve it. However, now the products they create come to my mind. For example, the pulleys. The child may not mind this, but s/he could do something different… I mean, activities were not difficult. For example, some of them designed a professional machine for transporting marbles into the nest, and used pulleys and cylinders, but C5 said that he would design a stair by using the kitchen paper rolls. He said that "Look my teacher, the parrot will jump from there to here." It was actually a solution from the child's viewpoint (T1, post-interview, micro-evaluation).

Observation findings support this view of the teacher. In fact, it was observed that children produced their own solution ideas, but the parents proposed a new idea rather than allowing the child to try her/his solution. As an example, in the third activity, children were challenged by asking them to produce more than one solution idea to move the marble to the parrot's house. C6 proposed eight different solution ideas to her/his father and the parent drew the plan of these ideas. These ideas were including to use a fire truck, to link the marbles to a rope and pass through a pipe, to use a crane carriage, and to use a pulley system to uplift three marbles to the parrot's house (see Figure 35). On the other hand, his parent proposed a different idea and they decided to construct the parent's solution. As seen in the following dialog between the parent and the child, the idea was to design a system with two baskets attached to the two ends of the rope, to put the marbles on one of these baskets and to put to stones on the other one to weight.

P6: There were five ideas, you got any more ideas?
C6: There's a rope running down here, but the marbles are here…
P6: Ok, I understood. Here there are three marbles in a basket. There's another basket here, right?
C6: Yes.

P6: The parrot will carry the stones up the hill. It will put a lot of stones, and the basket will become heavy. And the other basket is going to get into the house?
C6: When the stone goes down, the marbles will rise.
P6: This is a sensible idea. Do you have any other idea? (third activity, the step of think about it).

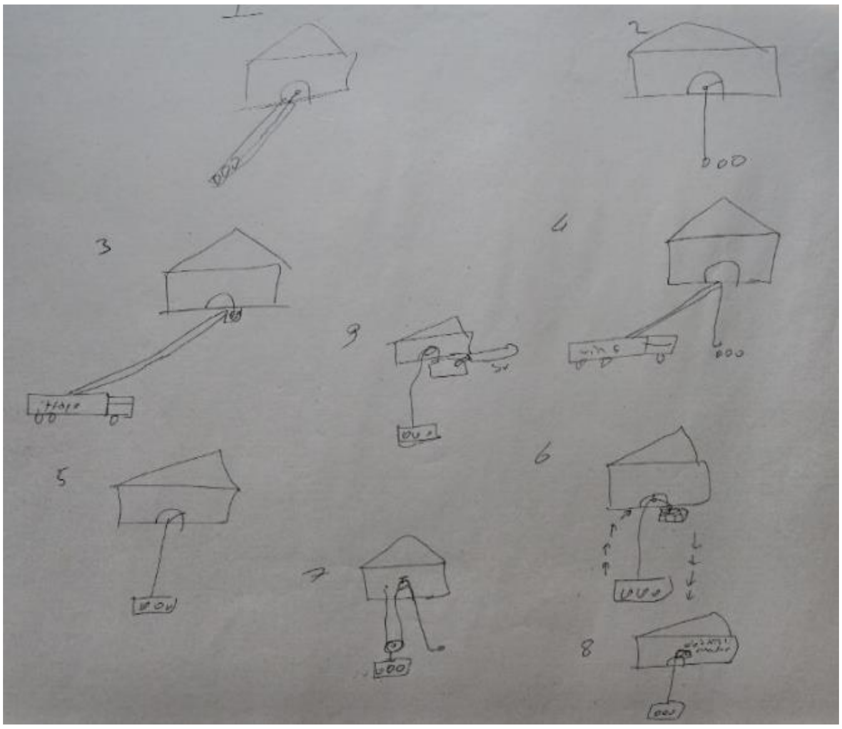

Figure 35 The plan of a parent-child groups including eight different solution idea.

The parent then created both the model and the design on his own (see Figure 36). That is, the child proposed several ideas, but none of them were tried. Besides, the task of the child was only to provide the parent with the materials, cut the tape and test the design. In fact, due to the parents' excessive interference, children thought that their task was to help their parents during the design process. The following dialogue in the model construction step of the activity between the parent and the child illustrates this finding.

P6: Let's do it.
C6: Dad, let's build a house here.
P6: It's not home, son, we're going to build a crane, and at one end, there will be three marbles.
C6: Let's we do a crane. Where is the paper (the paper on which they drew the plan)?
P6: Forget the paper, we don't need the paper. We're going to do a simple wheeled crane, and we don't really need a wheel.
C6: Dad, please let's do a wheeled one. I will keep the screws, okay?

Figure 36 The model and design constructed by the parent.

Parents stressed that their child lost their attention from time to time and the activity was continued by the parents. As seen in the following excepts, parents thought that the distraction of their children could be related to their interference, to the long duration of the introduction part of the activities and to not taking a long break in the process.

Sometimes my child was bored, the duration of the instruction part of the activities were long. In fact, the activities took about three or three and a half hours, and, the instruction part was long. I don't know if maybe we could have a break to get their attention, or a break could be given after the instruction part of the activities. Because they wanted to jump, run, and play and he was bored with sitting for a long time (P6, post-interview, micro-evaluation).

Children sometimes distracted because they thought that "my father/mother is doing it anyway" and they interested in playing with other things. (P2, post-interview, micro-evaluation).

To tell you the truth, I've never seen any missing points. The instruction part just took a bit long. The teacher kept the instruction part longer. I don't know if the kids maybe understand that way. I don't know if they're always teaching the lesson in the same way, but that part has come a little long (P8, post-interview, micro-evaluation).

According to the findings, another factor that led the parents to intervene was their hurriedness. In fact, some of the parents said they were in a hurry because they had to complete their design in a limited time, and they were trying to complete the design instead of their children. The following excerpts exemplify this finding.

The time was limited. That is, the child needs time to understand the problem. Let's say that she understood, but this time she was choosing shiny silvery materials. If she tries all the materials one by one, it takes too long. Therefore, we tried to complete the designs as immediate as possible (P1, post-interview, micro-evaluation).

In fact, my daughter was more interested in drawing and measuring. She wanted to draw more and to paint, but the time was limited. I thought that we should do our plan, model, and design as soon as possible (P8, post-interview, micro-evaluation).

Parents were seemed as becoming ambitious to complete as soon as possible and reaching a product. I would say we were impatient and behaved as hurried to produce something (P3, post-interview, micro-evaluation).

When the other children and parents completed their designs, we thought that "the others have completed, let's we also complete it. Not to be more beautiful than everyone else, but to finish and fulfill the purpose (P2, post-interview, micro-evaluation).

Parents also stressed that their children easily giving up under the difficulties, therefore, they obligated to undertake the design process instead of their children.

When he encounters with a difficulty, he easily gives up, gets bored and lays off. Another thing that attracts his attention immediately. He says he'll watch television, or he'll watch a movie. He was doing this also in the activities. When he fails, he leaves it rather than saying "I will do it" (P6, post-interview, micro-evaluation).

Another reason for parents' excessive interference might be giving importance to the product rather than the learning process itself. The data obtained both observations and post-interviews conducted with parents and teacher provided evidence for this finding.

The more aesthetical the design, the more pride it was for the child (P4, post-interview, micro-evaluation).

In the light of these findings related to the barriers of the EDCPI, some modifications were made on both parental training and implementation process of the curriculum. First, as mentioned before, the learning environment in the try-out study was a real preschool classroom, so some possible factors such as a large empty space and high ceiling that distracted children were removed. Moreover, all the visuals relevant to the activities were demonstrated to the groups by means of a projection in this classroom. In addition, by considering the teacher's feedback on the difficulty of observing each group due to the crowdedness, the number of participants in the try-out study was confined to five children and their parents who could attend all the activities. Again, based on the teacher's suggestion and findings obtained from the observation data, the activity templates were rearranged to include open-ended materials in model making and a new sub-step was added to the flow for the discovery of the materials. Another point revised before the try-out study was about the usage of open-ended materials in the construction of models. As explained in the previous sections, parental education was redesigned to include the scaffold method and some strategies that parents could use, and some points were emphasized to parents. These points were that the learning process was more important than the product, the design was not required to be completed, and therefore the parent should not hurry up and should guide the child to develop ideas about how to develop his/her design after the trials. The sections of the activities were shortened by subtracting the repeated parts every week (e.g. what is the engineering and what engineers do). Finally, a long break (half-hour) was added to the activity flow in order to enable children to rest and re-focus their attention on the activity.

To sum up, the micro-evaluation study enabled the researcher to make several revisions on the design principles, and on the curriculum and its implementation. In line with these revisions, the third prototype was developed based on data obtained from the micro-evaluation (see Figure 37). In this way, the third prototype which was the more structured version of the EDCPI was tested in a real preschool classroom with another sample of the target users. The following parts present information about the try-out study and findings obtained from this try-out study.

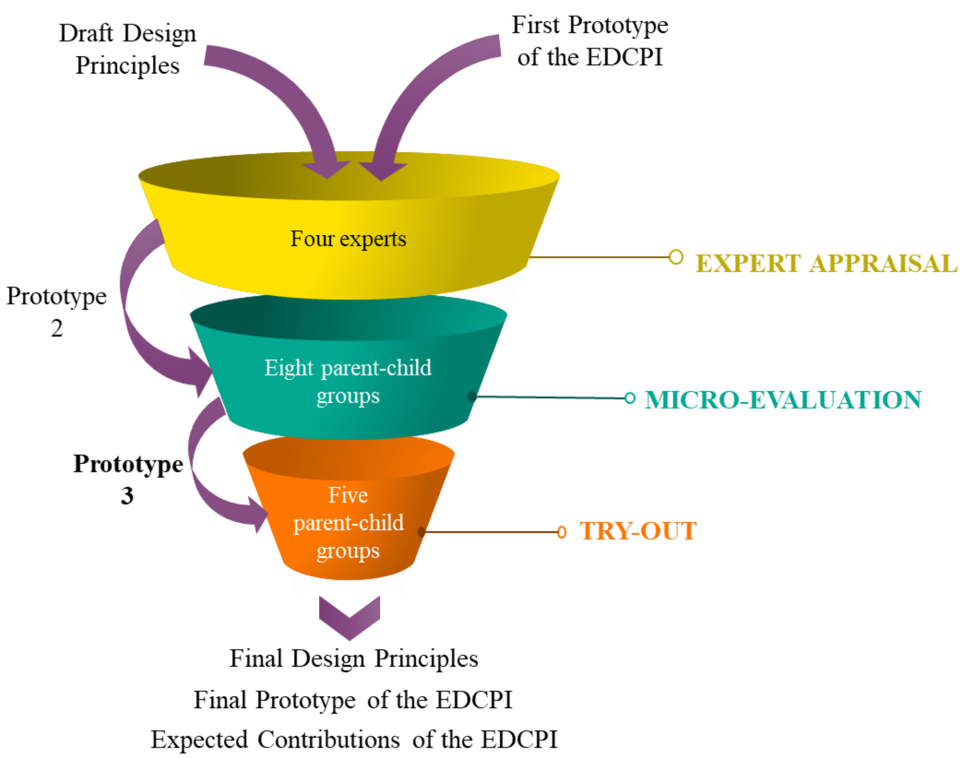

Figure 37 All the iterations conducted in the study and the inputs and outputs of the design process.

4.1.3 Third Iteration: Try-out Study

In the context of the try-out study, the third prototype redesigned in the light of the micro-evaluation findings was evaluated in terms of design principles, and practicality and effectiveness in preschool classrooms. In other words, the try-out study which was the final iteration of the current study provided the researcher to understand the possible contributions of the EDCPI to the participants and test the practicality of the third prototype in a real classroom environment. Thus, it was possible to determine whether the curriculum components needed any revision and to make the final modifications to reshape the curriculum as the final product. The try-out study was conducted with the participation of two preschool teachers from a public kindergarten in Kastamonu, five children enrolled in their classrooms, and parents of these five children. In the first three activities and in the last activity, participant parents were mothers of the children. In the fourth activity, fathers of the two children (C9 and C11) participated.

4.1.3.1 Findings of the Try-out Study on Learning Activities

In the micro-evaluation study, the third prototype was redesigned in accordance with the findings of the second iteration. In the second iteration, both the practicality and effectiveness of the EDCPI were focused on. Thereby, in line with the obtained findings from the second iteration, the content and design principles were revised. However, the third iteration (try-out study) revealed that further revisions should be carried out on this third prototype of the EDCPI. This section focuses on the findings concerning the learning activities and the conducted modifications.

- ***The First Activity: Don't Let the Parrot Get Wet***

Before the first activity, a one-hour teacher training was held with the participant teachers. At the end of this training, the activity template of the first week was given to the teachers, and they were asked to examine the activity, note the unclear points, and think about what should be done to improve it. One day before the implementation of the first activity, a meeting was held with the teachers again and the activity was discussed. In fact, T2 had an excuse for the first week and T3 expressed that she was willing to implement the first activity. In this way, it was determined which teacher would implement the activity.

In this meeting, some unclear points were determined and made clear for the teachers. Indeed, T2 expressed that she did not understand whether all the groups would come together and make a big roof, or each group create their own roof design. Moreover, she suggested that all groups come together and create a big roof together. This recommendation was discussed with the teachers and it was decided that each group would design its own roof by taking into consideration the possibility that the groups would become unfamiliar with each other and the process of activity as it was the first activity. T2 also asked whether they should memorize the activity template. The teachers were informed about that they did not need to memorize, they could carry along the activity template with them and follow the activity flow from the template. When it comes to the suggestions of the teachers about the modifications to the activity, they did not propose any modifications. As seen in the following dialogue between the researcher and the teachers, they wanted to see what was going to happen.

> *R: Anything else to talk about the event, anything you'd suggest?*
> *T2: In fact, we can see the first application and experience it and then offer suggestions.*
> *T3: We will see what happens (laughs) (informal interview before the first activity, try-out).*

Findings indicated that since it was the first activity and they had not implemented engineering or STEM in their classrooms before, teachers had some concerns and bias about the implementation process. Teachers expressed their thoughts as in the following statements.

> *Yes, we read the activity template. A curriculum was designed, and it will be implemented, but some troubles may emerge during its implementation process… When I read the activity, I thought that someone would be bored during the activity. I mean, someone from this group will get bored. Either the parent will be bored, or the teacher will get bored, or the child will be bored. Because there isn't a lot that everyone can participate actively. Okay, we will wait for the child to do something, but it seems very difficult for the parent to stay in the ground (T2, informal interview before the first activity, try-out).*

> *There are question marks in my mind because it is the first activity. I don't know what I will meet, what it will be like… Children in our classes are very active because we leave our students free and active in our classes. Therefore, I do not know how children will behave in such calmness (laughing) (T3, informal interview before the first activity, try-out).*

After the implementation of the first activity, it was noticed that these concerns disappeared in general. Besides, both the teacher and parent journals revealed that the learning process was very enjoyable for all the participants (see Figure 38 for some photos from the activity). The following excerpts provide evidence for this finding.

> *Overall, I think it was very good, they enjoyed it too. Even when the children came to the school on Monday, they said it was very nice. They enjoyed the activity and once again I realized that they like to work freelance. … Last week, I told you the time was long, the kids would get up, they'd be bored, they'd always want to go to the toilet. It's never happened (T3, informal interview after the first activity).*

> *It was a very enjoyable and fluent day which develops creative thinking and allows to brainstorm (T3, teacher journal for the first activity).*

> *My daughter solved the problem in a fun way, and with curiosity without getting bored. We tried to solve the roof problem by experimenting. We both had fun and learned together (P12, parent journal for the first activity).*

> *We've never had an experience like today. It was a nice work me and my child did together (P11, parent journal for the first activity).*

> *Although it was a very long process, he spent time without getting bored because he was always busy doing something (P9, parent journal for the first activity).*

Figure 38 The teacher, children and parents make a roof by using their bodies for preventing the parrot from getting wet.

On the other hand, during the implementation of the first activity, it was observed that some questions were not asked children by the teacher and this made difficult to assess the child in terms of some learning objectives. For instance, the teacher did not ask any question to the children about the differences between the first and last version of their design even if the activity template included sample questions relevant to this objective. Similarly, after the groups completed their plans, the teacher went to each group and asked the children how their roof would seem. All the children responded to this question by focusing only on the shape of their roof plan, and any additional question was not asked by the teacher about other attributes of their roof plans. After the implementation of the first activity, T3 stressed that she was concerned about skipping the steps of the activity and had difficulty in following the flow of the activity. She proposed the researcher to prepare a checklist of the tasks the teacher should perform in each step (see Appendix N). The following excerpt presents this modification idea proposed by the T3.

> *I've never had a hard time practicing the activity. I was just a little nervous when I looked at the activity template as I tried not to skip any step. For example, after I read the story, I thought that what step I was in now or whether I skip over any part of the activity. Besides the activity template, a brief explanation about the order of each step can be written on a small paper and given to the teacher. Like the task lists. For example, step 1. The teacher followed step 1 and put a check mark on the 1, and then proceed to the step 2. Therefore, I can say, "I'm here now." It could be something more practical (T3, informal interview after the first activity).*

In the light of these findings, in the second meeting, this issue was discussed with the teachers and it was decided to ask the sample questions in the activity template while the children shared their own design processes with other groups. It was told to the teachers that they could diversify this question by means of such type of questions “What's the shape of your roof; What materials will you use on this roof; Do you think that the material you use is waterproof or not; What is your measurement results; How many centimeters are the edges; How many centimeters are the corners?” These type of sample questions were also added to the next activities’ templates to make the child think about different characteristics of their designs. Moreover, by considering the teacher’s suggestion, a checklist including the tasks to be performed by the teacher during each step of the EDP was prepared for each activity. In addition, during the implementation of the activity, the teacher asked children to think about what they could use instead of the roof to prevent the parrot’s house from getting wet due to the rain. In fact, such a question was not taking place in the activity template and occurred during the activity flow. As seen in the following dialogue, although some of the ideas could not be tried due to the lack of materials like iron and umbrella, it was observed that children can offer different solutions and are very excited when testing their ideas (see Figure 39). In accordance with this finding, this activity was modified by being added a sample question which aimed to take and try children’s solution ideas before trying to the parrot’s solutions (see Appendix K).

Figure 39 Children are testing their solution ideas.

T3: The parrot can no longer use this hole roof. So, if we replace this roof with something else, can we prevent water from entering the house?
C11: Umbrella.
Teacher: Do you think that putting an umbrella on the roof may solve the problem?

C11: Yes.
T3: Ok. Any other ideas?
C10: Maybe we can make a roof made of iron.
C12: Let's put paper on the house.
T3: Should we try putting paper on the roof?
Children: Yes (Each of the children tried it).
T3: I have a suggestion about my house's roof. If we cover a piece of fabric on the roof, would it prevent the rain from entering the house (The parrot talks). Shall we try?
Children: Yes (They tried and observed).
T3: What do you think about could this fabric prevent the house to get wet?
Children: Could not prevent.
C11: Teacher, because there are holes here.
T3: There are holes on the fabric, right?
C11: I see water coming in.
T3: Let's take the parrot out and see if it gets wet (They touch the parrot)
Children: (laughs)
T3: How is it?
Children: Wet.

Finally, by considering micro-evaluation study findings related to the parents' needs to be supported in terms of home-based PI activities, a homework had been added to the first activity to reinforce the learnings at the workshop. At the end of the first activity, this homework was given to parents participating in the try-out study by writing on small note papers. In this assignment, the groups were asked to concoct a riddle about a technology they saw in their environment before they came to the next activity, and to investigate in which area the engineers producing this technology worked. When they came for the second activity, only two groups made this homework and the other groups had forgotten it. The findings showed that asking the riddle and trying to predict the answer was pleasing to the children and allowed them to think about different engineering areas. Below are the dialogues about this finding.

C11: It hears but has no ears, sees but no eyes, speaks but has no mouth.
T2: What an interesting riddle. It hears but has no ears, sees but no eyes, speaks but has no mouth (Children are laughing). What do you think this could be?
C12: Television.
T2: Can the television be the answer?
C11: No.
T2: Is not it? You know, I thought it was a television? Any other ideas?
C13: Telephone.
C11: Yes.
T2: C13 answered. Good for you. Well done to you C11, it was a nice riddle.

T2: Do you remember your riddle C12?
C12: Yes.
T2: Ok. Then ask us about your riddle.
C12: It works with electricity, has buttons, goes down, goes up.
T2: What do you think this could be? C13, do you have any idea?
C13: Elevator.
T2: Is it elevator?
C12: Yes.

T2: Well done. So, which engineers design the elevator?
C9: Elevator engineers.
T2: Is it a new engineering field?
C12: Mechanical engineers.
T2: Yes, the mechanical engineers may have designed the elevator, and the electrical engineers might have helped them (the step of think about it, second activity, try-out study).

- ***The Second Activity: Can the Turtle Cross the River?***

Following the implementation of the first activity, researchers and teachers reunited within the week. In this meeting, a brief evaluation of the first activity was carried out and the activity template of the second activity was given to both teachers. In addition, in this meeting, T2 expressed that she was willing to implement the second activity. In the second meeting held in the same week, teachers and researchers discussed the second activity. The second activity was reviewed with the teachers and some points which were unclear for them were clarified. T2 pointed out that not only chemical engineers but also chemists work on production of the medicine. According to her, the sample question in the activity template regarding whether engineers can also produce medicine (Can engineers also produce medicine?) should be changed. By considering this suggestion, the sample question was revised and changed as “Do you think engineers can work on the production of medicine?”

At this meeting held to evaluate the second activity, teachers were reminded that they should go to the children one by one and learn the details of the plan they had drawn. Moreover, teachers were reminded that they should help children with recall their design processes when they share their designs with other groups. Teachers were told that they could achieve this by asking some questions to make children compare the first and last version of their designs, and some examples were given to these questions (e.g. In your plan, you said you were going to build a wooden bridge, and in the design, I see you build a bridge of plastic bottles. Why did you change your mind? Have you tried using the woods? When you first tested your design, I think you had a problem, tell me what happened). In addition, the second activity was designed to contain the material limit to challenge children a little more. Therefore, in the micro-evaluation study, kitchen paper rollers, rubber bands, clear tape, pipet, and wooden tongue depressors were presented to the groups to be used in their bridge designs. On the other hand, in the try-out study, teachers stated that material restriction could prevent children's creativity and cause similar designs to emerge. The teachers expressed their thoughts about this issue in the following way.

Wouldn't it be better to have a variety of materials? If we limit the materials, very similar designs can occur. So, everyone uses the pipette, or everyone uses the rolls as the abutment of the bridge (T2, informal interview before the second activity).

I think the same products will probably emerge. We say this based on our experience in the classroom. Besides, the derivatives of a material type may be limited. I mean, there could be three different materials instead of five made of cardboard (T3, informal interview before the second activity).

By considering this recommendation, the material restriction in the second activity was abolished and a large number and a variety of open-ended materials were presented to the children. Figure 40 demonstrates the materials used for the second activity in the try-out study. When compared to the ones in the micro-evaluation study, it was observed that many different bridge designs emerged in this activity made of different type of materials. The following excerpts provide evidence for the creativity demonstrated by children in this activity.

I have better observed that children can add a lot to their creativity if they are freed. There is no limit in creativity, as long as the children are given the opportunity (T2, teacher journal for the second activity).

Figure 40 The materials provided to the groups to create their designs in the second activity.

My child learned what would happen if more material than the required was used, the importance of measurements and to choose solid material. I wish the we would be provided with the opportunities for making our dreams come true. I wish we hadn't grown up in a rule based and rote-learning system. I have seen how different dreams are, how wide the minds of children can think (P13, parent journal for the second activity).

As in the first activity, at the end of the second activity, the groups were given note papers on which a new homework was written. In this homework, parents were asked to take a picture of their children on a bridge in the city they lived or in any city they visited, and to talk with their children about the characteristics of this bridge (e.g. the materials used in the construction of the bridge, who used this bridge, where the bridge is situated). When they came to the next activity, four groups (C13 and their family did not participate in the third event) had done their homework. Their photos on the bridges were projected onto the wall and children introduced the bridge and its characteristics. It was observed that children did not forget the features of the bridges about which they talked with their families and that they were happy to share their photos with other groups.

- ***The Third Activity: Marble Carriers***

After the second activity, the researcher visited teachers in their school and conducted a meeting with them. At this meeting, the templates for the third and fourth activities were delivered to both teachers. Both were asked to review activities until their next meeting and to note their modification ideas. After a couple of days, the teachers were revisited, and the activity was discussed together. Both the teachers expressed that the third activity was difficult for the preschool age group. On the other hand, when their modification ideas were asked, both did not propose any change. The following dialogue between the teachers and the researcher provides evidence for this finding.

T3: I think that the third activity is very difficult.
T2: Its implementation is troubled.
T3: Yes, its implementation will be troubled.
R: How so? Are the concepts difficult?
T3: No, I thought what I'd do if I were in their shoes. I would put the parrot in the flying balloon with the marbles. So, I do not think that they can bring out very creative ideas, I think they will clog in this activity. I think you're going to have difficulty in implementing, too (says to T2).
T2: So, we may have difficulty in reaching the conclusion.
T3: Exactly.
R: I did not understand. Do you think it is difficult to conceptually or...?
T2: It's hard for children to make a product.
T3: It's problem for children to make a product, because the problem is difficult to make a product.
T2: They're expected to think of a few ideas, but it seems to me that they're not going to produce too many ideas.
T3: Exactly so, so you can get stuck, I think you cannot continue the activity. I think that parents will be…
T2: As parents will be more active.
T3: That's exactly what I think.
T2: It seems to me too.
R: So how can we do it in a simpler way? So, if we were to give these concepts again, but want to make it simpler?
T2: So, the parrot will help the turtle. I don't know, I didn't think right now. Can we make another system from this system? I couldn't think of anything. I mean, I never thought about changing the system. And now I have my head stopped.
T3: Of course, if the system will use load and force, there is nothing to do already. My head is so full right now.
T2: I'm suffering from abdominal pain; I could not adapt.

R: You can think, teacher, I'm not in a hurry.
T2: So, my brain is empty. So, let's implement it without any change and see. We will live and see.
T3: I wonder what they will do. I mean, even when I read it, I said, "What could I do?" If I and my son had been involved in this activity, I think my son would definitely leave the activity, so I think he couldn't do anything. So, I think a little creative thinking isn't enough for this activity (informal interview before the third activity).

As seen in the above presented dialogue, the teachers were somewhat biased towards the activity and they did not provide any modification idea on the activity before the implementation. On the other hand, as a modification idea, the researcher had recommended T2 to ask the children what they could do to move the marbles to the parrot's house. If none of the children report any idea, she had been told to make children think by asking them such type of questions: "Have you seen people who have moved from one house to another before; How are those people carrying their stuff to the upper floors of the apartment; How do we get to the high floors of the apartments?" On the other hand, as seen in the following excerpts, during the implementation of the activity, the teacher did not ask the children what they could do to move the marbles to the parrot's house and immediately gave examples of the elevator and moving.

T2: Think about what we talked about. What could be our mission today?
C10: Getting the parrot home.
T2: Will we get the parrot home? Or else?
C11: Marbles.
T2: Yes, we will get the marbles to the parrot's house. Look, the house is on the tree, somewhere high. So how do we get these marbles up? Have you ever seen people move?
C11: Other people were carrying.
T2: How other people were carrying?
C11: By truck.
T2: The stuff came by the house with the truck, but our apartment is upstairs. Is the truck going upstairs? So how do you get to a high place?
C10: By climbing.
T2: Like the spider man, right?
C12: With the elevator.
T2: Yes, by using the elevator. The elevator is taking the lift us up, right?
C10: With the pulleys.
T2: Yes, the elevator works with the pulleys (the step of think about it, third activity, try-out study).

In addition to giving these examples, the teacher was also in a hurry in the remaining part of the activity. According to the flow of the activity template, groups would present their designs at the end of the activity. In the second activity, one of the groups (C11 and P11) finished the design before the other groups. On the other hand, the teacher asked this child to present her design and asked other groups to listen to this child. Although all the children planned to design an elevator system, none of them except for the C11 had used the pulley yet.

After C11 presented her design, it was observed that all the groups used the pulley and similar type of designs revealed (see Figure 41).

Figure 41 The designs created by children for the problem of the third activity.

The teacher said that although children produced different ideas at the planning phase, they were influenced by each other's ideas during the design phase and similar designs emerged. On the other hand, the parents stated that in this activity they observed development in their children and that their children experienced many new concepts (see Figure 42). T2 and the parents expressed their evaluation regarding the third activity in the following manners.

> *They learned new knowledge and concepts and tried to reach a conclusion. I thought that they did not reflect their imagination to this activity. During the implementation phase, they concluded that they were affected by each other, especially by an idea. Although there were different ideas in the drawings, they were influenced by each other in the model and design phases and in the selection of materials. This situation prevented the emergence of original products (T2, teacher journal for the third activity).*

She heard some of the concepts she had never heard before in her life thanks to today's activity and experienced these newly learned concepts in concrete terms. I realized that my child had more fun than other activities (P11, parent journal for the third activity).

Compared to the previous activity, I saw my son improve himself better. I've observed what he can do with less interference. Thank you (P10, parent journal for the third activity).

He tried to think more creatively and seek solutions to the problems. I've observed improvements in their ideas. It was a difficult activity, but I'm glad we reached the goal (P9, parent journal for the third activity).

Figure 42 Children experience the concept of force through their bodies.

While the teachers and the researcher came together for evaluating the activity, they discussed how this activity could be improved. T3 proposed to make the challenge of the third activity clearer for the children by concreting it. According to her, the teacher could bring a heavy blanket to the class and tell the children that s/he wanted to remove this blanket in the closet. S/he could propose children to lift the blanket and then she could ask children's how to lift this blanket into the closet. In other words, T3 expressed that the problem of not being able to carry the blanket can be revived by the teacher and the problem can be presented to the children in a more fun and concrete way through such type of example. By considering this suggestion, in the second activity, the phase of the presentation of the problem to was modified and this example was added to the template (see Appendix K).

- ***The Fourth Activity: Let's Keep the Green River Clean***

Since in the school where the activity was held there would be another activity at the weekend when the fourth activity was planned to carry out, it was decided to implement the third activity on Saturday and the fourth one on Sunday of the same weekend. After all parents were approved for this change, the researcher visited the teachers in their schools and gave them the templates of the last two activities. T2 was willing to implement the fourth activity, while T3 was willing for the last one. The teachers reviewed both activities until the second meeting held before the weekend. In this meeting, both the third and fourth activities were discussed with the teachers and they proposed their modification ideas.

The first modification idea was regarding the beginning of the activity. T2 stated that when children come to classroom firstly, encountering an environment polluted with wastes may increase their motivation for the activity. According to the teacher, children could wear gloves in their hands and collect these wastes in the classroom and they could be asked what might have caused this pollution. T2 proposed that after resting the answers of the children, the concepts of pollution and waste could be talked about. By considering the recommendation of the teacher, the introduction part of the activity was modified, and the activity was begun with a polluted classroom (see Figure 43). The findings showed that such an introduction to the activity surprised and excited children.

Figure 43 At the beginning of the fourth activity, children are cleaning the class from various wastes.

Another modification idea was proposed by T3. The second prototype of this activity (the version implemented at the micro-evaluation study) had included experiencing children the concept of the filter by filtering tea. On the other hand, T3 suggested that before explaining the concept of filtering to the children several concrete experiences could be added to the process, with strainers of different sizes and different characteristics. According to her, for example, the flour and corn grains could be mixed together in a bowl and the children could separate these two substances using the strainers. T3 proposed that, as she proposed for the previous activity, the teacher could animate this problem (I will make a cake, but the corn grains are mixed into the flour, look at this. Do you have any idea how to separate these corn grains from flour?). This recommendation of the teacher was taken into consideration and the activity had been modified before it was implemented (see Table 28).

Table 28

Modifications on the third week's activity (Let's keep the Green River clean)

First version of the beginning of the activity	***Modified version of the beginning of the activity***
Before the activity starts, the learning of the previous activity is remembered. The day starts by discussing what the engineers do, what engineering areas are learned, how the designs of the engineers affect our daily lives, and which of the objects we see around us can be technology. In the previous activity, it was talked about the problems that children work on together with their parents and produce solutions. It will be asked if they make other designs at home. If they do, they are asked to explain which problem they are doing to solve through this design.	The activity starts when children come to class and realize that the classroom environment is full of waste. It should be ensured that the waste is of a type that does not pose a threat to the health and safety of children (used packaging paper, batteries, disposable pet bottles, pieces of paper ...). Children are asked if there is anything that attracts their attention in the classroom. Once the answers have been received, you will be asked what this class environment looks like and whether this pollution in the class will be harmful to people who use it. Then all children put on their gloves and collectively clean the classroom environment from these wastes. It is talked about how the class looks after the cleaning, how it smells, and whether it is a health hazard for people who use this environment. The children then hear a crying sound from the corner of the classroom (the teacher sings). They are asked who might be coming from that voice. The turtle appears, saying that s/he is very upset and that s/he is asking the children for help for something very important this week. The children are asked why the turtle may be sad and crying.

Thus, the children firstly experienced how the corn grains and the ground could be separated through the strainers and then they were asked whether we could use the strainer to separate solid and liquids. After it was explained to children that filtering was meant to separating the particles mixed in the liquids. Then they experienced filtering the tea. As seen in the following excerpt, try-out findings regarding the fourth activity showed that children were excited when separating flour and corn grains and filtering tea (see Figure 44).

YA: I wonder what we will do with it (she is showing the strainer and teapot).
C12: Tea.
C11: Are we going to make tea? (laughing)
T2: Look at these (she I am putting the jars in which there are flour and corn grains on the table).
C11: We will make popcorn? What we will do?
Children: (Laughing)
T2: Now, we will separate the corn grains from the flour. How do you think we can?
C10: One by one.
T2: Wouldn't it be a waste of time if we took one by one?
C10: Yes.
C11: By shaking it (she is showing the strainer).
T2: Let's we shake it (They are shaking the strainer and laughing)

Figure 44 Children explore the strainer and the concept of the filter.

In addition to these modifications conducted on the activity before the implementation, try-out study signified that the activity should be revised in terms of the difference between garbage and waste concepts. In fact, the third prototype of the activity included an explanation related to the definition of the concepts of waste and garbage, and the teacher touched on their difference. On the other hand, the findings showed that children confused these two concepts despite the teacher's explanation. The following dialogues between teacher and children, and between one parent and child provided evidence for this finding.

T2: What do you think we should do to prevent the environmental pollution you see in these pictures?
C11: We have to dump the garbage.
T2: Where we should dump the garbage?
C10: We have to dump the garbage in the dustbin.
T2: We just talked about waste. Were there any wastes in these pictures?
C10: Yes.
T2: Where should we throw the waste?
C10: To the dustbin.
C11: To the recycle bin.
T2: Yes, we should dump garbage to the dustbin, and wastes to the recycle bin.

P11: (After the introduction part of the activity, a break is given. They eat cake during the break and in the meantime, the parent asks the child) What do you think the package of this cake is? Where are we supposed to throw?
C11: To the dustbin. There is a dustbin near the teacher's desk.

Considering this finding, this activity was modified for the final prototype of the EDCPI by adding a home-based activity to strengthen the learning at school. In this modified version of the activity, children are expected to design a recycling bin in their homes by following the EDP steps with the guidance of their parents and collect the wastes on it by considering their types. This recycling bin should have a function (e.g. its cover might be opened by stepping on a pedal) and appropriate to collect waste according to their variety (e.g. glass, paper, metal). Within this homework, parents are also asked to speak with their children about what is waste and what is garbage and the difference between them and then take away the collected wastes to the waste collection center in the city with their children. This section can also be organized by the teacher as a field trip to the waste collection center in the city with the voluntary participation of all parents and children. In this way, parent-child groups can have a chance to see where the waste they collect goes and how they are treated here. The final prototype of the EDCPI (see Appendix K) includes this modified version of the activity.

Parents' and teacher's evaluations of the fourth activity supported the findings that the activity was efficient and fun for children. The teacher and parents expressed their thoughts about their activity experiences in the following way.

I have discovered the importance of the environment, nature, water and the need to protect it from the eyes of children. It was an activity in which children were involved. Efforts to reach the result were more intense (T2, teacher journal for the fourth activity).

My child learned the concept of filters for the first time. The importance of equilibrium and the water resistance of the materials were well established. From now on he will wonder how the sea was cleaned (P13, parent journal for the fourth activity).

It was a creative activity, it was hard to understand what the children might think, but the results were good (P9, parent journal for the fourth activity).

It was an activity that showed that our children should be sensitive to the environment and should keep their environment clean and what they should do for this (P10, parent journal for the fourth activity).

My child realized that perforated mechanisms could be used to clean the waste, and in doing so he understood how to install a system without touching the dirty water. I have observed that she has chosen the appropriate materials (P11, parent journal for the fourth activity).

- ***The Fifth Activity: Let's Get the Car to the Mechanic***

In their last meeting to discuss the activities, teachers and the researcher reviewed the fifth activity. In this last activity of the EDCPI, a parent-child group would work together with another parent-child group(s) and tried to get the parrot's car to the car mechanic by collaborating with each other. In doing so, the groups had to establish a system moving with a marble that would be rolled from the parrot's house. In the meeting conducted before the implementation of the activity, T3 reflected that this was a difficult activity for this age group. The teacher's expressions reflected that she focused on what children would produce rather than the learning process. She expressed her thoughts about the activity in the following way.

> *According to me, the idea of building a system was more difficult than the activity with the marbles (meaning the third activity). I said the third activity was difficult, but when I read this activity's template, I back down. The steps are always the same, but I do not know, my hesitation is about that they cannot produce anything (T3, informal interview before the fifth activity).*

On the other hand, teachers did not propose any modification idea about the activity. Therefore, the activity was implemented by T3 without any modification. The findings indicated that after the implementation of the activity, the focus of the teacher shifted from the product to the learning process. The teacher stated that the activity was challenging but effective in concretizing some concepts of physics. The following excerpt provides evidence for this finding.

> *I think that children understand the meaning of concepts such as force and incline. In our classrooms, although we touched on concepts such as speed and force in our stories or conversations, I realized that we could not embody these concepts. I realized that we had to embody these concepts by means of kind of activities. It was a very enjoyable and challenging activity. They learned new concepts and experienced the relationship between these concepts in a concrete way (T3, teacher journal for the fifth activity).*

Findings regarding this activity also indicated that some of the children had troubles in working collaboratively with another parent-child group. In fact, due to the number of participant parent-child groups was five, two different group was created. The first group consisted of two children (C10 and C12) and their parents, and the second group consisted of remaining three children (C9, C11, and C13) and their parents. The grouping was based on the fact that children were in the same class at their school. During the activity, it was observed that collaborating with another child was also a challenge for some children. For example, C10 and C12 did not establish almost any interaction with each other. In fact, as seen in the following excerpts, C10 had some troubles in sharing both materials and the tasks with C12.

C10: We're not taping it like that. Not like that (While C12 is trying to tape the wooden blocks).
C12: Mother, can you give me the pencil?
C10: That is my pencil.
P10: Does it matter?

Today working with another group challenged my child. Their ideas did not match (P10, parent weekly journals for the fifth activity).

On the other hand, it was observed that, especially in the second group, children enjoyed working together, producing ideas and trying these ideas. It has been observed that children try to roll the marbles repeatedly from different inclines and try to improve their designs continuously (see Figure 45). As below presented, the parent journals also supported this finding. In the light of these findings, any modification did not conduct on the last activity after its implementation.

Figure 45 Children trying their design ideas.

They noticed the factors affecting the speed of falling of an object. They had the pleasure of working as a group. We worked with the group, we produced solutions, we had a pleasant day even though we could not reach the goal (P9, parent journals for the fifth activity).

We tried to solve our problem by trying again and again. In short, today we both had fun and learned together (P13, parent journals for the fifth activity).

Today we have seen that incline and speed are effective factors in providing motion. My daughter learned that the incline should increase in order to have a marble more rapid. It was a group activity and I observed that the children were more willing and sociable at this activity (P11, parent journals for the fifth activity).

4.1.3.2 Findings of the Try-out Study on the Assessment Tools

As before mentioned, in the try-out study, it was aimed with the iteration to improve the design of the EDCPI from the target users' (preschool teachers, preschool children, and parents) perspective and estimating the expected practicality and effectiveness for target users. Therefore, as an important component of the designed curriculum, the assessment tools were tested and revised by means of try-out study. Try-out findings indicated that the observation form was not practical for the teachers. According to them, filling the observation form was time consuming and this was a disadvantage for the teacher. T3 expressed her difficulty about the observation forms in the following manner.

> *In my opinion, instead of writing an explanation for each indicator, we could tick the substances that we observed and write a general explanation in a paragraph. Because I've never been bored in the implementation part of the activities, but I was bored in the evaluation. I think this is a disadvantage for the teacher, so I think the evaluation part could be shortened. In my opinion, I say the same thing repeatedly, so I think we had difficulty in evaluations, not in applications, so the form to be filled was challenging us (T3, post-interview after the try-out study).*

Similarly, T2 expressed that fulling the observation forms for each child individually was time-consuming for her and she had difficulty in completing all of them. On the other hand, she thought that since this was a thesis study it was normal to use such a detailed assessment tool and teachers could assess their children in a briefer way when they used this curriculum in their classrooms. She expressed her views in the following way.

> *The stage of observation was difficult. It was supposed to be a serious time… I mean, which teacher can fill these observation forms for 20 or 30 children? As this is a thesis study, it is necessary to follow a certain procedure. We will not be able to implement this curriculum in such a detailed way. This can be eliminated and reduced according to the activity as in learning objectives in the ECE curriculum (T2, post-interview after the try-out study).*

These findings indicated that the observation form should be rearranged in a less time-consuming and practical format for the observers. Therefore, it was modified by transforming it in a format which enabled the observer to put a check mark on the observed indicators. In this modified version, after ticking the indicators s/he observed, the teacher will make a general evaluation for the performance of the child in the activity. A separate section was added to the end of this form for this general evaluation.

In addition to the practicality of the observation forms, there were also some findings concerning the clarity of the learning objectives constituting the observation form. These findings and conducted modifications on the learning objectives for the fourth prototype in line with these findings are presented in the section about the barriers of EDCPI.

The implementation process of the try-out study also signified the need for some additional modifications. In fact, as stressed in the previous sections, different from the micro-evaluation, in the try-out study, children constructed their models with the open-ended materials. In this regard, children also demonstrated some skills relevant to choosing appropriate materials to construct a model, testing the constructed model, and interpreting the results. These skills were also important in EDP and had a role in shaping the design idea for children. Therefore, the try-out study revealed that the third prototype of the observation form should include these skills. In this context, three more indicators (determines the materials needed for constructing the model; tests her/his model; generates new ideas for design in accordance with the experiments on the model) were added to the second learning objective related to engineering skills. The final version of the observation form is presented at Appendix K.

4.1.3.3 Findings of the Try-out on Design Principles: Final Design Principles

- ***Developmentally Appropriateness***

Developmentally appropriateness of the EDCPI was represented in this study under four sub-principles and the try-out study provided findings regarding with all these sub-principles. First, try-out findings revealed that EDCPI should be revised in terms of clear identification and articulation of the learning objectives. Data obtained from the teachers both during the implementation process and after the implementation reflected that teachers experienced some troubles in understanding and interpreting learning objectives and indicators of the EDCPI. These problems mostly related to the similarity between the learning objectives or the indicators representing the objectives. Teachers stated that when they read some of these objectives and indicators that form the items of the child observation form, they seemed very similar to each other and thus they had difficulty in making the evaluations. For example, T3 expressed her views about the clarity of the learning objectives taking place in the observation form in the following manner.

> *Particularly in the part about feelings, some goals were very close. For instance, "the child is involved in the activity without being bored and distracted"; "the child appears to be eager and willing to participate in the activity"; "the child is interested in the parrot's problem." All of these seem to come to the same thing (T3, informal interviews after the first activity).*

In the meetings conducted with teachers throughout the implementation process, considering their need for clarity of some learning objectives and indicators, the differences between the learning objectives they had difficulty in understanding were explained to the teachers. Post-interview findings indicated that T3's views about the learning objectives were changed after the implementation process. In fact, T3 thought that the learning objectives were clear. According to her, the problem was the reverse items in the observation form. As seen in the following excerpts, T3 expressed that the reverse items which were the opposite statements of some learning objectives confused her.

> *The goals were clear, but I think there was a disadvantage in terms of clarity. I think there were statements opposite of each other. When you fill one of them, the opposite one would automatically be empty. This problem can be solved by opening parenthesis and instructing the teacher to make an explanation for this observation if s/he has observed the inverse of the indicator (T3, post-interview, try-out).*

The underlying rationale of using reverse items on the observation form was to allow the observer to comment if the child exhibited a behavior opposite the indicator. After this finding, these reverse statements were removed from the observation form and a brief explanation was added to the instruction of the general evaluation part for the observers. In this statement, as T3 recommended, the observers were asked to make an explanation if they observed any behavior that might be the opposite of any these learning objectives and indicators taking place in the observation form (see Appendix K).

When it comes to T2's views about the clarity of the learning objectives, as seen in the following excerpts, post-interview findings pointed out that teacher had still troubles in understanding the difference between some learning indicators. T2 stated that she understood the differences between the objectives or the indicators but stated that it was difficult for her to interpret the observed behavior by considering these differences during her activity implementations.

> *For example, was there a big difference between (the child discovers the available materials in terms of restrictions) and (the child brainstorms about how the materials can be used or transformed)? ...These differences between them you explained to me requires a detailed observation. I mean, these goals were written by considering those details, but... On the other hand, my point of view in my application is not the same as what you tell me about the difference between these two. I mean, I can't interpret the indicators in such a detailed way when I apply the activities. So, according to me, the learning objectives need to be clearer (T2, post-interview, try-out).*

By considering this finding, it was thought that exemplification of relevant indicators with behaviors demonstrated by children would eliminate the difference in the point that T2 stated in the above excerpt. Therefore, these two indicators mentioned by T2 were exemplified through some behaviors exhibited by children during the micro-evaluation and try-out studies and by the literature (see Appendix K).

Another sub-principle of developmentally appropriateness was the consistency of the EDCPI with classroom experiences and the real world. The data obtained from the try-out study reflected that EDCPI was in line with the activities implemented by the participant teachers in their classrooms, but EDCPI activities focused on the children's trials and the steps of the EDP. Both the informal interviews conducted with teachers during the meetings and the post-interviews provide evidence for this finding. In other words, the teachers stated that they also implemented activities with open-ended materials in their class, but these activities did not include the steps of the EDP and that the children did not conduct experiments on materials and emerging products. For instance,

> *Already in the same logic as in here, I was giving the children open-ended materials, and they chose the materials they wanted. But our designs did not include the trial and error. For example, we were designing houses and let's say this house was made of cardboard. We were not thinking of their share of reality and were not trying our designs in terms of different problems and limitations. For example, we did not experiment with the water resistance of this house. We were just in the pursuit of creating something unique, just the creativity of the activity. However, these were the things children should see, we were not doing them. Indeed, in terms of content and application, we have missing points in our kindergartens. For example, experimenting with materials is one of them. Apart from that, it was already parallel to the applications in the classroom (T3, post-interview, try-out study).*

> *So yes, we were trying to design new and different things to children by giving materials, but we didn't do it by following the specific steps or experimenting, sampling and giving children the opportunity to try one by one, as we did in engineering activities here. Even if we did, it was not so detailed as in these activities (T2, post-interview, try-out study).*

When it comes to the appropriateness of the EDCPI with the developmental levels, needs, and characteristics of the children, findings obtained from the post-interviews conducted with participant parents and teachers and the parent journals provided evidence for this sub-principle. T2 stressed that producing solutions to engineering problems with open-ended materials might not address the interests of every child in the classroom. On the other hand, findings obtained from parents and the other teacher pointed out that EDCPI was a curriculum including interesting and fun activities for preschool children which were suitable for the developmental level of this age group and addressing children's learning and curiosity needs. The following excerpts include the views of T2 and then the views of some parents and T3 in this respect.

> *In fact, their interest is different from each other. On the other hand, when the aim is to engage in the material and trying to reach a conclusion related to this material, yes… I also observe in my classroom that sometimes there are children who produce very beautiful products. But there are also children who think that painting or cutting the given material is enough. I mean, this is a situation that changes according to the person rather than a general situation. Therefore, I think that the appropriateness of the activities to children's interest varies from child to child (T2, post-interview, try-out study).*

> *I think the most important points were to address the child and explain the problem in accordance with the child's level. I think it was done very effectively. Using hand puppets to explain the problems, the problem was reduced to the lives of children. When the children understood the problem, they tried to search for solutions (P9, post-interview, try-out study).*

I notice that my child is more curious in learning every day and his interest in activities has increased (P13, parent journal for the fifth activity).

I think that the learning activities were very appropriate for children's developmental needs and interests and they took pleasure. They were appropriate for their interests and needs, because they observed reality. For instance, after the first activity, I predict that they have had the opportunities to examine the roofs of the houses (T3, post-interview, try-out study).

When it comes to the flexibility and adaptability of the EDCPI, findings reflected that EDCPI was a flexible curriculum permitting to adapt to different learning environments and to different characteristics of the target users. As the implementers of the curriculum, participant teachers stated that EDCPI enable teachers to adapt to an outdoor environment, to different age groups, and to parents and children with different characteristic. According to them, this is an issue related to the teacher who will implement it.

The curriculum we implemented within this study can be adapted to different classrooms and the interests and needs of children and parents in these classes. It may be implemented even in an outdoor classroom if the weather conditions are appropriate. It can be reduced to a smaller age group, for instance to 4 years. I think that the curriculum gives an insight for the teachers about how to adapt it to their classroom. According to me, if the teacher wants to adapt any content to her/his classroom, s/he can improve it or simplify it (T3, post-interview, try-out study).

Ultimately, we apply activity plans or use the learning objectives taking place the Turkish ECE curriculum, and all the preschools in Turkey also implement it. However, everyone is adapting the curriculum to their classrooms by making changes on it in accordance with their own region and environment. These factors may be effective even in the selection of the materials. Therefore, as in our curriculum, this curriculum can also be applied across the country but the changes that will be made on may vary in accordance with the region (T2, post-interview, try-out study).

T2 also pointed out that the activities were limited to 3 hours per week during the try-out study, therefore, these 3 hours were only followed by tracing the EDP steps. On the other hand, she expressed that when any preschool teacher applied this curriculum with their parents and students in their classrooms, s/he could spread the activity to a whole day and thus add play, drama and movement activities among the steps. According to T2, the flexibility of the curriculum allows teachers to make some changes and additions on them.

Normally, I'm already in the classroom for over 3 hours with the kid. This was an activity conducted at the weekends and everyone allocated a certain time to take part in this activity. However, when I apply this curriculum in my classroom, I can extend it over all day and add something to it. Besides, we can add a lot between the activity flow, we can turn it into a little different. Here everything is going step by step, I mean, children are drawing plans, creating the models, determining the limitations, measuring. But when I apply it in my own class, I can add something between these steps, and when they get bored, I can add something extra. In this regard, I think that the curriculum provides the teachers with the flexibility (T2, post-interview, try-out study).

Data acquired from the teachers in the post-interviews conducted after the implementation process of the try-out study indicated that EDCPI was a curriculum providing child with learning experiences which coherent to the Turkish ECE curriculum (MoNE, 2013). In fact, teachers expressed that EDCPI activities were not only related to engineering learning objectives but also to many objectives and indicators in different developmental fields taking place in the current curriculum. The following excerpts provide evidence for this finding.

> *In addition to engineering related learnings, activities were involving number recognition, counting, measuring, usage of fine and large motor skills. These are all learning objectives in our ECE curriculum (T2, post-interview, try-out study).*

> *In the engineering activities we applied in this process, there were a wide variety of learning objectives which also take place in ECE curriculum (T3, post-interview, try-out study).*

- ***Learning Process supported by Parental Scaffolding***

After the micro-evaluation, the characteristic of EDCPI which was about the learning process supported by PI had been modified as learning process supported by parental scaffolding. The content of the parental training had been redesigned in this respect. Findings obtained from the try-out study supported that the learning process in the EDCPI should be based on parental scaffolding. The findings indicated that parents tried to use the scaffolding strategies explained to them in parental training while guiding their children's learning process. As an example, for the first two activities, children and parents made measurement together. During this process, parents provided their children with guidance in the usage of the measurement tools like tape measure and ruler. In subsequent activities, some parents encouraged children to take measurements on their own. These parents provided guidance again by recommending re-measurement together if the child measured incorrectly (see Figure 46). Similarly, parents accompanied the children during the first two weeks of material discovery and selection. They also guided the child to consider the limitations of the problem in selecting materials. In the next three activities, most of the parents left their choice of materials entirely to their children and refrained from directing them. Instead of telling the child the right material if the child chose unsuitable materials, they gave the child the opportunity to try and decide if this material would not meet limitations. In other words, in the try-out study, parents were more open to their children's ideas and suggestions and to try them out and were more aware that this was a learning process for the child. The following dialogues between parents and children provides some examples.

> *C9: (the child tries his design, but the design does not completely cover the roof. Then he takes some wooden tongue depressors from the table on which there are materials).*

P9: Are you going to make it taller by using these?
C9: Yes.
P9: Ok, let's see it.
C9: We will put them like that (putting the tongue depressors side by side) (first activity, the step of fix it, try-out).

P11: (they use pipettes to make models, they don't have enough of the long pipettes) Shall we use these white ones? Are they the same length?
C11: (she compares the lengths of the two pipettes by measuring them). No, they are not. Teacher, can I take another pipet which has the same length as this one?
T3: Yes, sure.
P11: (after the child returns to her desk) Did you find?
C11: Let's try. (after measuring two pipettes) It is shorter (fifth activity, the step of try it, try-out).

Figure 46 Children make measurement with their parents' guidance.

As seen in the above examples, in the try-out study, parents mostly chose to allow their children to try their ideas and gave them the opportunity to explore the answers rather than giving the correct answer to the child. On the other hand, just as in micro-evaluation, there have been instances of occasional over-intervention by parents. As in the micro-evaluation, some parents intervened with the child at various stages, from material selection to improvement efforts. Besides, in the try-out study, it was observed that when parents intervened the process, their children were more passive and experienced some problems in focusing on the activity. To illustrate,

C12: 34 (after measuring the length of the roof of the parrot's house).
P12: 37 (she measures the length herself). Honey, let's sit, we measured it (first activity, the step of think about it, try-out).

P12: It should be our car (makes a car model by using wooden blocks). Shall we put the marble like that (she puts blocks on both sides of a horizontal block)?
P10: Well, does the marbles fit in it?
C10 and C12: Does not fit (after trying).
P12: Hımm. Ok. That means we should make it wider (fifth activity, the step of try it, try-out).

Table 29

Final design principles of the EDCPI

Characteristics	***Design Principles***	***Rationale for not making modification***
Balance in terms of learning objectives	EDCPI should be designed as a balanced curriculum in terms of objectives under main learning areas (knowledge, skills, dispositions, feelings).	Observations reflected that EDCPI learning activities provided a learning process in which children had the opportunity to obtain engineering and STEM-related knowledge and skills, and experience various thinking ways and feelings. Moreover, findings obtained from children and presented in the following section also supported that EDCPI contributed to all these four areas. Therefore, it was conjectured that learning objectives were distributed these four main areas in a balanced way.
Learning by discovery	EDCPI should encourage children to be active in their education process and to explore the available materials and the answers to their questions.	It was observed that learning by discovery was supported by enabling children to use open-ended materials in model making and adding a sub-step to the flow to the exploration of the materials. Teachers expressed that it was an important achievement for children to see even the material that was not suitable for the problem by themselves and to decide which material was appropriate through concrete experiences. By considering these findings, it was assumed that EDCPI enabled children to learn by discovery.
Learning by designing	Learning activities within the EDCPI should be designed as enabling children to identify a problem, propose solutions, test and improve these solution ideas.	It was observed that EDCPI enables children and parents to experience the design process step by step. Observations also revealed that preschoolers were able to demonstrate the skills required for EDP such as identifying a problem, proposing possible solution ideas, following a plan, constructing design, and improvement of it in the light of the testing results. Concordantly, it was conjectured that EDCPI provided to learn by designing.
Providing preschool children with experience in STEM	EDCPI should be designed as a transdisciplinary curriculum that enables children all STEM disciplines under the real-life framework.	Both teachers and parents stated that the learning process in EDCPI allowed children to experience many concepts of science and mathematics in a concrete and real-life connected way. According to teachers, such an engineering education process enabled children to acquire not only knowledge and skills related to engineering but also ones in social and scientific aspect. Therefore, EDCPI was assumed as a curriculum providing STEM integration.
Learning experiences based on creativity and usage of daily life materials	EDCPI should be based on the usage of daily life materials to sustain engineering learning in the environments outside the school and to use their creativity.	According to the teachers, all children followed the same steps during EDP, but even though they were sometimes influenced by each other, the idea of the solution, the material they chose and the product they designed were different from each other. In addition, parents stated that open-ended materials were used by children in a creative way that they had never thought of before. These findings signified that EDCPI allowed them to unearth their creativity.
Versatile assessment process	EDCPI should allow for the evaluation of each child individually and in a versatile manner.	The try-out study revealed that all the assessment tools of the EDCPI (observation form, child interviews, and questions asked children during the activities) enabled both the researcher and teachers to evaluate children's learning in different domains. In this way, EDCPI was assumed as allowing the versatile assessment of children.

As seen in the examples, some parents were tended to interfere with the process. On the other hand, in the try-out study, children were more involved in the activities compared to micro-evaluation. Since their design process mostly reflected their own ideas, children were more eager to test and improve their solutions. By scaffolding them, their parents supported children in the process of thinking like an engineer, creating solutions to problems and uncovering and developing their creative potential. These findings signified that PI was more supportive in the engineering education of preschool children when it was provided in the form of scaffolding. The try-out study also provided findings regarding the other six design principles of the EDCPI. Since these findings were mostly based on the researcher's inferences on her classroom observations, these were presented in Table 29. After the modifications conducted throughout the iterations of the current study, the design principles of the EDCPI took its final form. Figure 47 summarizes these design principles which constitutes the main characteristics of EDCPI.

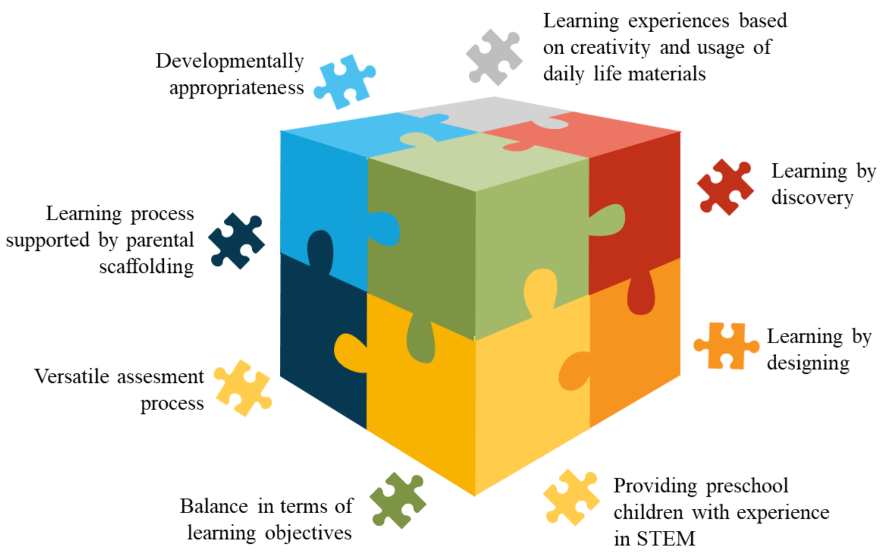

Figure 47 Final design principles of the EDCPI.

4.1.3.4 Findings of the Try-out Study regarding the Facilitators of EDCPI

In addition to identifying the key characteristics of the curriculum, this study also aimed to identify the barriers and facilitators of EDCPI from the participants' point of view. Parents reflected that the EDCPI learning process was well-planned and that this process consisted of activities that attracted the attention of children, giving them the opportunity to learn through trial and error. According to the parents, all these features were facilitators of the EDCPI. In addition, parents reflected that other facilitators of the EDCPI were the implementation of the curriculum in a real preschool classroom, giving short breaks, having a small number of participants, usage of various visuals, of puppets and of a wide variety of materials. The following excerpts exemplify parent's ideas about the facilitators of EDCPI.

> *It was so nice to let them try. They could try again and again. At the end of the activity, even the child's design was not successful, the message was given to the child "ok, your design was not adequate just this time, even so, you were successful. These are very important things for the preschoolers (P13, post-interview).*

> *It was very nice to present many different open-ended materials. There were many options in front of the child, and all of them, for example, that many different types of materials could be used in bridge construction. I couldn't think of the use of pet bottles in the bridge construction. I thought we were just waiting for the kids to pick the right one. I looked at one of the children who made bridges from the pet bottle. So, I thought it could be done. I think this is a very enriching one, a good choice for the child's education, which is an example that shows how many different materials can be utilized (P11, post-interview).*

> *I think the video related to how to use the ball in the latest system, and the projected visuals facilitated the process. It's something we know, but it's something you don't think immediately (P10, post-interview).*

> *Making each job separate was a facilitator. Like, plan first, make a model now. These are always supportive things because it could also be said to child that think and do without drawing a plan (P13, post-interview).*

> *Activities were interesting for the child. Every week on Friday, she says, "Mom, when are we going to college?" She was curious, she was wondering what to do (P12, post-interview).*

When it comes to the teachers' views about the facilitators of the EDCPI, as parents stressed, teachers reflected that usage of a variety of the materials facilitated the process. Moreover, according to the teachers, the existence of the auxiliary staff (pre-service teachers) in the education environment, children's self-confidence and the involvement of the parents were other facilitators of the EDCPI. To illustrate,

> *I think the richness of materials is very important in this process. In my opinion, providing the child with too much material and letting the child to think about what can be done with these materials will have a positive effect on her. Even though they saw similar materials in daily life, it was still fun to examine and work with them. Apart from this, the positive support of the family also facilitates the process. Besides, confidence of children makes the process more fun. This is related to the children's profile. Some children can express herself/himself better while others cannot. Maybe someone has a lot of skill, but s/he won't be able to express herself/himself. Maybe if we had done it with a little more self-confident, high-creativity children, maybe we would obtain a lot of more different products. However, in a normal classroom, there are children of both types (T2, post-interview).*

> *There were pre-service teachers who provided us with technical support. In my opinion, this was a huge advantage for a teacher. Indeed, when you were alone in the education environment, there may be a lot of things that escaped the attention. Therefore, to see more than one eyes is an advantage (T3, post-interview).*

4.1.3.5 Findings of the Try-out Study regarding the Barriers of EDCPI

Try-out study shed light not only facilitators, but also barriers of the EDCPI from the teachers' and parents' viewpoint. According to the two parents, there were no barriers of the EDCPI. On the other hand, the remaining three parents reported that existence of the different stimuli in the education environment and some parents who were excessively interfering were the barriers of EDCPI. Two of the parents reported that, some materials which could be used in decoration and the stimuli in the environment caused children to distract. In addition, another parent reported that some parents interfered with their children by giving the child a loud directive. According to this parent, in such a condition, the intrusive parent affected not only his/her own child, but also other children. The following excerpts exemplify parents' statements.

> *There were different stimuli, the children's mind was going to other things from time to time. I mean, she had some trouble focusing on the problem, I've observed that she could not adapt (P12, post-interview).*

> *I didn't see anything blocking the education process. Only my daughter was distracted. I think it's distracting the ornamental materials. They were put there for different purposes and could be used in different ways from the decorating. On the other hand, maybe she would not so eager for the activity if these materials were not (P11, post-interview).*

Teachers also reported their views about the factors that barrier the EDCPI and its implementation process. As parents did, T3 pointed out the distraction of children due to the stimuli in the environment. On the other hand, she emphasized that this was related to being in a different learning environment from their own classroom and was not related to the EDCPI.

> *In fact, in the classroom, there was almost no material because you had already collected. But for example, the children wanted to enter the tree in the book center. Indeed, you know, anything can distract their attention. This was unavoidable and was not related to the curriculum or its implementation, because no matter where they were, children give their attention to different stimuli in a different environment from their class (T3, post-interview, try-out).*

In addition to T3, T2 also presented their opinion about the barriers to EDCPI. According to T2, difficulty of evaluating the learning from time to time might be a barrier for EDCPI. T2 reflected that, sometimes children affected from each other, therefore she had trouble in observing their learning. Different from T2, T3 reflected that some children had difficulty in working collaboratively in the last activity. According to her, this might be a barrier for EDCPI. In addition, both teachers reported that timidity of some children might be another barrier of the implementation process of the curriculum. Teacher expressed their views in the following ways.

It was effective that we could not get some things from the children. Sometimes they were affected by each other. Sometimes, I was undecided whether the child influenced from others. It may be a disadvantage to be affected by others when it comes to seeing what the child can and cannot do. In addition, at the point of implementation, for my part, sometimes I did not get feedback from children. These feedbacks were ultimately more important to us in terms of the current implementation. You don't know what you think when you can't make the child speak, you don't know if s/he has an idea. There were some children who drew her/his plan well and made a good model, but s/he did not respond any question I asked (T2, post-interview)."

There were children who were timid, not wanting to talk. Besides, they experienced difficulties in group work. They needed to understand the cooperation in the group, but they had a hard time. Everybody had a mind of its own (T3, post-interview).

4.1.4 Assessment Phase: Findings on the Contributions of the EDCPI

The final phase of this DBR was the assessment (summative evaluation) phase. As before-mentioned, micro-evaluation did not provide reliable observation findings regarding children's learnings within the dimension of skills, dispositions, and feelings. Therefore, evaluation of the contributions of the EDCPI to the children was carried out through the findings obtained from the try-out study. The contributions of EDCPI to parents and teachers were evaluated based on the data of both implementations. The following subsections present the findings of EDCPI's contributions to the participants.

4.1.4.1 Possible Contributions to the Preschool Children

The design and development process of the curricular components of the EDCPI, which were the learning objectives and indicators, learning activities, and assessment tools, were presented in the prototyping phase. In addition, the findings of the try-out study revealed that the final prototype of EDCPI was a completed product for the intervention used to support preschool children's learning in engineering and STEM and to foster parents in learning about early childhood engineering and the ways of supporting it. In this section, the expected contributions of the EDCPI to preschool children were examined as the answer for second research question of the study. Findings obtained from child observation forms and pre-and-post interviews, and the interactions occurred during the implementation of the activities were analyzed to reveal expected contributions of the curriculum. The contributions of EDCPI to preschool children were examined in four main dimensions as knowledge, skills, dispositions and feelings through the findings obtained from the try-out study.

4.1.4.1.1 Children's Knowledge about Engineering

The third prototype of the EDCPI includes five knowledge-related learning objectives and fourteen indicators relevant to these objectives. In this part, findings are presented on the extent to which preschool children achieved each of these learning objectives and indicators. Pre-and post-interviews carried out with children were examined to investigate how EDCPI contributed to children in terms of engineering knowledge.

As aforementioned, the first learning objective was related to children's comprehension of the meaning of engineering and technology. In this context, it was expected that children would tell what engineering and technology was, and that engineers would be able to express human life easier and be familiar with the steps of the EDP. The findings of the pre-interviews revealed that participant preschool children had limited knowledge about engineering. In fact, when the cards representing various professions were shown to them (see Appendix B), children recognized all professions other than engineering. Only one child recognized the civil engineer illustrated below. According to other children, these persons depicted on the cards could be a repairman, a professor, a constructor or a robot maker. To illustrate children's answers,

R: Okay. Let's look at this.
C12: It's a robot manufacturer.
R: What does she do?
C12: She makes the robot.
R: What is the profession of people who make robots?
C12: I think it's a robot job. This girl is fixing the robot (pre-interview, try-out).

R: ... Let's look at this picture. What can be this man's job?
C10: Construction.
R: What does he do in this picture?
C10: He draws how he will make the building.
R: Does the constructors draw what the buildings look like?
C10: Yes (pre-interview, try-out).

Similarly, when children were asked what engineers do, only the children whose mother and/or fathers' profession were engineer were able to answer, other children reported that they did not know. As mentioned earlier, one of the participant children in the micro-evaluation and three of the participants in the try-out study had engineer parents. The findings obtained from the pre-interviews reflected that these children had an initial idea of what engineering is and what the engineers engaged in, while the others had not any knowledge about the engineering profession. On the other hand, the knowledge of these children whose parents were an engineer was limited only by the work of their parents. In other words, according to the findings, even children whose parents were engineers had little initial knowledge of what engineering is and what engineers do.

Participant children had limited initial knowledge about technology as well as engineering before the intervention. Indeed, four of the children reported that they had never heard of technology before and they did not know what technology means. They also had some troubles in predicting which object around the classroom could be technology. On the other hand, one of the children stated that technology produced by people. As seen in the following dialogue, he also gave a correct example to the technological tools from the classroom and evidenced his response with a correct reason.

R: Have you ever heard of technology before?
C9: What people do. Developing models.
R: Do you think there is technology in this class?
C9: Blackboard.
R: Blackboard can be a technology, why?
C9: Because it enables us to write on the wall.

Findings related to the children's initial knowledge about engineering revealed that children thought that engineering was beneficial for people. On the other hand, all one had trouble explaining why they thought so. In a similar vein, children did not demonstrated knowledge about the steps of EDP. In fact, in the pre-interview, none of the children correctly ordered the cards representing the steps of the EDP (see Table 30).

When it comes to the post-interview findings, it was revealed that the first and third indicators of the first learning objective of the knowledge dimension were achieved by children. In fact, findings indicated that after the intervention children had knowledge about what the engineers do, and about the engineers were working to make people's lives easier (see Table 30). However, as before the intervention, except from one child, most of the children had difficulty in defining technology after the intervention. This was the same child who defined technology in the pre-interview. Post-interview findings revealed that the technology definition of the child included engineers after the intervention. The following dialogue provided evidence for this finding.

R: Do you know what technology mean?
C9: The things made by people.
R: Which people?
C9: Engineers.

Since this learning indicator was not reached by children both in micro-evaluation and try-out study, it was not given place among the learning objectives in the final prototype. In addition, the first learning objective (The child comprehends the meaning of engineering and technology) was modified as "The child comprehends the meaning of engineering." Even if most of the children did not define what technology is, when they were asked to give examples of technology, all children managed to give correct examples (see Table 30). Similarly, as before the intervention, all the children reported that engineers benefit people.

Table 30

First learning objective and relevant indicators in knowledge dimension

Objective	***Indicators***	***Pre-interview***	***Post-interview***
K1: The child comprehends the meaning of engineering and technology.	Tells what engineers do.	*R: What engineers do?* *C9: They set camera. My father is a camera engineer.* *R: What your father does?* *D: He repairs the computer.*	*R: What the engineers do?* *C9: They construct houses.* *R: What else they do?* *C9: Machines.*
		R: Have you ever heard of a profession as engineering? *C12: I heard; my father's profession is an electronic engineer.* *R: What do engineers do?* *C12: They look at computers.* *R: What are they looking at?* *C12: They're investigating something. That's what my father does.*	*R: What do you think engineers do?* *C12: Home, telephone.* *R: What else do they design?* *C12: Tablet, computer.* *R: Why are they doing this, tablets, phones, houses?* *C12: For us to look at.*
	Tells what technology is.	*R: Do you know what technology means?* *C10: No.* *R: Look at this class. Do you think there might be technology in this class?* *C10: Not.*	*R: I have some cards. Look at this.* *C10: This is a computer.* *R: Do you think this computer could be a technology?* *C10: Yes, because we can learn something with the computer.*
		R: Have you ever heard of technology? *C12: No.* *R: See this class. Do you think there's technology in this class?* *C12: Yes. That computer has the keys there (showing the keyboard).* *R: Why did you think it is a technology?* *C12: Because I thought it was broken.*	*R: Do you know what technology means?* *C12: I can't remember.* *R: Think about your house. Do you have technology at home?* *C12: Yes. There's a dishwasher, a washing machine, a fridge.*
	Expresses that engineers are working to make human life easier and meet people's needs.	*R: Well, do these engineers benefit people?* *C11: Yes.* *R: How do they benefit people?* *C11: I have no idea.*	*R: What do engineers do?* *C11: Buildings, bridges, roofs, houses.* *R: Yes. So, what is their duty, why do they do it?* *C11: For people and animals.*
		R: Do the engineers benefit people? *C13: Yes.* *R: How they benefit for people?* *C13: ...*	*R: Do the engineers benefit people?* *C13: Yes, they do something for them. They design house and washing machine.*

Note: If the child exhibits at least half of the indicators in this learning objective, it can be said that s/he achieved this learning objective.

In contrast to the pre-interviews, in the post-interviews, children presented reasons for the idea that engineering was beneficial for people. As seen in Table 30, these reasons presented by children indicate that they understand that engineering makes human life easier, and the third indicator was reached by children. This conclusion is supported by the findings presented in the following paragraphs regarding the second learning objective. Finally, according to the findings, the fourth indicator of the first learning objective was not reached through the EDCPI. Only one of the children correctly sorting the cards representing the EDP in the post-interview. In fact, the children dominated the story told through the cards, but they were having trouble sorting the cards according to the order of events. In addition, it was observed that children used expressions reflecting the EDP, such as designing, experimenting, retrying, while explaining the story in the cards. To illustrate,

> *The bird came and settled on the girls' hand. Then, the bird drops down from her hand. Then the girl thought and tried, but the bird turned down and could not fly. Then she retried. She achieved (C10, post-interview, try-out).*

> *The crow fell, and something came to the child's mind. Flying wings came to the child's mind. The child made the wings. Then she designed something. Something like a cloth. Then she wore a wing to the bird. Then the bird flied but turned down (C9, post-interview, try-out).*

Another purpose of EDCPI with respect to knowledge was to enable the child to recognize the engineering products utilized in daily life. In this regard, it was expected from children to exemplify the technologies they used in their daily life, to know the difference between natural objects and engineering products, and to express that most of the artifacts utilized in daily life were produced by engineers. Pre-interview findings revealed that some of the children had difficulty in recognizing technologies on the cards showed to them. One of the children expressed that all the objects shown were technology, because they were all harsh. This child also reported that engineers designed harsh things. Another child had an initial understanding about technologies made our life easier and she recognized most of the showed technologies. On the other hand, when she asked whether the shown technology designed by an engineer, she associated all her answers with her father who was an engineer. In other words, most of her answers were true but her reasons were irrelevant. To illustrate,

> *R: Let's look at this one. What do you see in this picture?*
> *C12: A computer.*
> *R: Do the computers are technology?*
> *C12: Yes, because when you press the keys, something comes out of the screen.*
> *R: So, do engineers design computers?*
> *C: Yeah, because I broke the keys, so my dad fixed it (C12, pre-interview, try-out)."*

There were also two children who recognized most of the technologies even if they could not define what technology is. One of these children focused on the ability of the technologies facilitate our lives, while the other mentioned the mechanical properties of technological objects. According to the first one, engineers design all these technologies because they were a constructor. On the other hand, according to the second child, most of technologies were designed by constructors rather than engineers. The following dialogue exemplifies their thinking ways.

R: Let's look at this card.
C9: This is a washing machine.
R: Is it a technology?
C9: Yes, because it is washing our clothes for us to, we don't get tired.

C10: This is a plane.
R: Do the planes are technology?
C10: Yes, because it has props and motors. When they revolve, the plane flies.
R: Do the engineers design plane?
C10: No. Plane constructors design planes.

Pre-interview findings also revealed that some children thought that engineers could not design huge constructions like bridges. Besides, all the children reported that medications were not a technology and engineers did not have a task in producing medications. According to them, medications were produced by pharmacies. Pre-interview findings also revealed that three of the children could distinguish the natural objects from the technologies, but two of them could not. While one of these two children did not provide any reason for her answer, the other child reported that since the pinecone and tree branch were harsh, they were technology and they were designed by engineers. When it comes to the post-interview findings related to this learning objective, findings revealed that two of the children had difficulty in recognizing the technologies. One of these children considered technology only the objects including a working system, although he recognized most of the technologies shown on the cards. According to him, the bridge and medicine were not technology because they did not have a working system. Similarly, according to the other child, an object must be able to move in order to be called technology. Therefore, she did not consider some objects such as bridge and computer as technologies. The following excerpts provided evidence for this finding.

C10: This is a house.
R: Does engineers design houses?
C10: They draw a plan and show the constructors, then the constructors build the house.
R: Ok. Do you think home is a technology?
C10: Yes, because there is a working something inside them. Like elevators.
R: Ok. So, there are some houses do not have elevators. Do you think they are a technology?
C10: No.

On the other hand, three of the children did not have any difficulty in recognizing most of the technologies on the cards. These children were also aware that all these technologies shown on the cards facilitated our lives in different ways (see Table 31). These findings signified that the first indicator of the second learning outcome was reached by some of the children. When it comes to the second indicator, before the intervention one of the children did not recognize the natural objects. Findings of the post-interviews revealed that all the children were able to distinguish the natural objects from the human-made objects, and thus reached the second indicator. Finally, with the third indicator, it was aimed to make children aware that the engineering touched on almost everything in our lives. On the other hand, post-interview findings revealed that none of the children used such an expression. Therefore, it can be said that the third indicator of the second learning objective was not reached in the try-out study through the third prototype of the EDCPI, as in the micro-evaluation study. Based on the findings obtained from micro-evaluation and try-out study, it was concluded that making a generalization that almost everything that had a final purpose in the world was designed by engineers might not be an appropriate indicator for this age group.

The third learning objective was about to the exploration of different fields of engineering. In accordance with this learning objective, learning indicators consisted of giving examples to the technologies produced by different fields of engineering and explaining how engineering was effective in many areas of human world. Before the intervention, children had very limited knowledge of different engineering areas. Three out of five children had an engineer parent, but two of these children did not know the work areas of their parents. Only one of them reported that her father was an electronic engineer (see Table 32). Findings obtained from the post-interviews revealed that none of the children remember the name of the different fields of engineering. Three of the children, when reminded of the names of the fields, gave false examples to the technologies produced by the engineers in these fields. To illustrate,

R: There were variety of fields of engineering. Do you remember?
C9: House, car.
R: I will remind you. For example, civil engineering. What do civil engineers do?
C9: House, computer, sofa.
R: Ok. So, what do electrical engineers do?
C9: S/he cuts off the electricity (post-interview, try-out).

C11: Teacher, we saw an engineer when we were going to home.
R: Really?
C11: Yes, we saw an engineer who builds construction.
R: What we call them?
C11: Home engineer (post-interview, try-out).

Table 31

Second learning objective in the knowledge dimension and findings from try-out study

Objective	***Indicator***	***Pre-interview***	***Post-interview***
K2: The child recognizes the engineering products used in everyday life	• Exemplifies technologies s/he sees around her/him.	*R: What do you see on this card?* *C10: A cellphone.* *R: Do you think the cellphone is a technology?* *C10: Yes, because it opens when you pressed on its button.* *R: Do engineers design cellphones?* *C10: No, it is made in phone stores.*	*R: Let's look at this one.* *C10: A cell phone.* *R: Ok. Do you think the cellphone is a technology?* *C10: Yes.* *R: Do engineers design cellphones.* *C10: Yes, because it can open and shut. It also has a charging adapter.*
		R: What do you see in this picture? *C12: A washing machine.* *R: Do the washing machines are technology?* *C12: Yes, because we put our clothes in it, and then close its door. Then we put detergent, then we get out of the wet clothes from the machine. We hang them and they get dry.*	*R: Let's look at this.* *C12: It is a washing machine.* *R: Is it a technology?* *C12: Yes. It washes our clothes, and it turns. We're putting detergents here.* *R: Do engineers design washing machines?* *C12: Yes, to keep our clothes unclean.*
	• Distinguishes natural objects from the human-made objects.	*R: What do you see on this card?* *C11: It is a tree branch.* *R: do you think it can be a technology?* *C11: No, it is not.*	*R: Ok. Let's look at this card.* *C11: A tree branch.* *R: So, is it a technology?* *C11: No. It is used to make a fire.* *R: Do engineers design tree branches?* *C11: No, it grows itself.*
		R: Let's look at this card. What is this? *C9: A pinecone.* *R: Ok. Do you think is it a technology?* *C9: No, because it is not made by people.* *R: Do engineers design pinecone?* *C9: No. How will they design it (laughing)?*	*R: So, look at this one.* *C9: It is a pinecone.* *R: Is it be a technology?* *C9: No.* *R: Do engineers design pinecones?* *C9: No. Anybody design it, it grows itself.*

Note: If the child exhibits at least half of the indicators in this learning objective, it can be said that s/he achieved this learning objective.

The other two children were able to give examples to the technologies produced in these areas when the names of different engineering fields were reminded. The parents of both children were engineers, and one of these children was 72 months old and the other 73 months. Different from micro-evaluation findings, for this learning indicator, in the try-out study, although the name of the field was similar to the produced technologies in this field, three of the children had difficulty in exemplifying the technologies. However, when the pre-and post-interviews of the remaining two children were compared, it was found that awareness was raised for different areas of engineering and the technologies produced in these areas. In other words, according to the interview findings, this indicator was exhibited by some but not all children (see Table 32).

Table 32

The third learning objective under the knowledge dimension and excerpts from try-out findings

Learning Objective	***Indicators***	***Post-interview***
KO3: The child discovers different fields of engineering.	Gives examples to the technologies produced by engineers from different fields.	*R: What do civil engineers design?* *C10: They design the constructions.* *R: What kind of constructions they design?* *C10: Houses, pools, shops.*
		R: What do you think mechanical engineers design? *C12: They design machines.* *R: What kind of machines?* *C12: Refrigerator, washing machine, and dish washer.*
	Explains how engineering is effective in many areas of the human world.	*R: Would I ask you a question? If the engineers did not exist, did we make our jobs easier or harder?* *C9: Harder.* *R: For instance, is there something that engineers produce, and you would have a hard time without?* *C9: My toys. I cannot design cars; I only draw it.* *R: Is the toy cars benefit for you?* *C9: Yes, I play with them.*

Note: If the child exhibits at least half of the indicators in this learning objective, it can be said that s/he achieved this learning objective.

When findings were investigated in terms of the second indicator, it was found that all the children were aware of the effect of engineering on the human world. Their statements reflected that children were aware that engineering and engineering products existed in many areas of our lives. The examples given by children and their explanation about the effect of engineering on our lives are presented in Table 32.

The fourth learning objective was related to the children's comprehension of everyone can be an engineer and think like an engineer. In this regard, children were expected to give examples to the engineers from different genders and the situations in which any family members think and work like an engineer. In the pre-interviews, two of the children reported that girls would not be an engineer. In fact, the mother of one of these children was an engineer. However, the child knew that only her mother was an engineer, but he did not know the details about her mother's profession (e.g. her field and what she does in her workplace). Similarly, the other of these children had a father who was a computer engineer. The child reported that his father's profession was the camera engineering and that his father fixed the computers and installed cameras in hospitals. According to him, girls could not be an engineer because they would be afraid of heights. On the other hand, when the statements after the intervention were examined, it was observed that the ideas of these two children changed. Indeed, in the post-interviews, all the children reported that girls also could be an engineer. When the children were asked if they had another engineer they knew except for their parents, only one gave an example (see Table 33). Three of the children also reported that they worked like an engineer in their home after the workshop. The examples given by these children to the situations in which they think and work as an engineer are presented in Table 33.

Table 33

The fourth learning objective of the knowledge dimension and excerpts from try-out findings

Learning Objective	***Indicators***	***Post-interview***
K4: The child comprehends that everyone can be an engineer or think like an engineer.	Gives examples to engineers from different genders and to technologies they produced.	*C12: Do you know I had a big sister. She is a constructor.* *R: Is she a civil engineer?* *C12: Yes, but she has not become yet.* *R: I wonder what will she design?* *C12: She said me she would design a house and a school.*
	Gives examples of situations in which s/he or someone around him/her thinks like an engineer and produces a solution.	*R: Have you or any other family member ever work like an engineer before?* *C10: I made a car from the halva box. But the wheels are not turning because they are glued.* *R: Maybe you can develop it.* *C10: Yes. Maybe I can cut a little paper, and then I can rotate and glue it.*
		R: Have you or any other family member ever work like an engineer before? *C13: I did a really tough car.* *R: Really? Which materials did you use?* *C13: I did it with my father's old wood. I taped them each other.*
		R: Well, other than our activities, have you ever done engineering at home? *C12: Yes, I did.* *R: What did you do?* *C12: We have a grandmother in our house, so small. We did it at school. I tried to make a flying device to bring this grandmother to her grandchild.* *R: Really?* *C12: I did it.*

Note: If the child exhibits at least half of the indicators in this learning objective, it can be said that s/he achieved this learning objective.

The final learning objective under the knowledge dimension was related to comprehending the role of engineering and technology in the development of our world and society. Post-interview findings obtained from the try-out study revealed that the last learning objective was reached by all the participant children. In fact, findings indicated that children could compare today's conditions with the older times conditions by considering the contribution of engineering and technology to our society (see Table 34).

Table 34

The fifth learning objective under the knowledge dimension and excerpts from the try-out findings

Learning Objective	***Indicators***	***Post-interview***
K5: The child comprehends the role of engineering and technology in development of our world and society.	Compares today's conditions with the old times when engineering and technology have not developed.	*R: You said that mechanical engineers work on production of washing machines. Do you think the washing machine is useful to us? C13: Yes, it washes our clothes. R: What if there were no washing machines? C13: Our clothes remain dirty. R: What were the people living in ancient times? C13: They were washing their clothes in places where water was replenished. R: Were they using a machine? C13: No, they were washing with their own hands.*
		R: What were the children living in the old days doing when they didn't have toy cars? C9: They were making a little iron or stone wheel and playing with them.
	Gives examples of how engineering and technology affect our society (positively or negatively).	*R: Can I ask a question? You said that the engineers benefit us. What happened even if they do not exist? C12: Nothing in our house would be. Dishwasher, refrigerator. R: Do you think life is harder or easier when there's no dishwasher or refrigerator? C12: Harder. R: For example, old people ... C12: They were washing their laundries by their hands. R: Do you think their life was easier or ours? C12: Ours.*
		R: So, do you think it's harder to wash the laundry by hands or by machine? C13: Washing by hands.

Note: If the child exhibits at least half of the indicators in this learning objective, it can be said that s/he achieved this learning objective.

4.1.4.1.2 Children's Engineering-related Skills

The second dimension of learning was engineering-related skills. EDCPI aimed at improving children's engineering-related skills. In fact, as mentioned in the previous sections, the second prototype (the version used in the micro-evaluation) included seven learning objectives and totally 46 indicators (13 of them were reverse items). After the micro-evaluation, the observation form had redesigned. This revised version used in the try-out study included seven learning objectives and 37 indicators (9 of them were reverse items). On the other hand, it was recognized during the implementation of the try-out study that there should be some additional indicators related to the skills demonstrated by children during the model construction with open-ended materials. Therefore, from the second activity, three new indicators were added to the observation form (S2.5; S2.6; S2.7). Therefore, these three indicators also took place in the final prototype of the EDCPI under the second skills-related learning objective. As explained in the related part, findings of the try-out study also revealed that one of the indicators (S5.2) should be integrated into another indicator rather than defined as a separate item. Finally, by considering the suggestion of T3, after the try-out study, the reverse items taking place in the observation form was removed. Instead, an explanation was added to inform observers to make explanations about their observations on the behaviors demonstrated by children contrary to the learning objectives and indicators. In this way, the final prototype of the observation form included totally seven learning objectives and 30 relevant indicators within the skills dimension (see Appendix K).

In order to determine to what extent skills-related objectives and indicators were reached through EDCPI, both the researcher and the teacher-filled observation forms, the researcher's field notes, and classroom work records were utilized. Learning objectives and indicators are presented below with the instances observed in the try-out study.

Skills-related Objective 1 (S1): The child identifies an engineering problem which can be solved by developing an engineering product through observation and inquiry (NGSS Lead States, 2013; NRC, 2012).

S1.1: Identifies the problem or the need.

T3: Do you think this roof prevent the parrot from getting wet?
C10: It cannot prevent.
T3: Why?
C10: Because of the hole (first activity).

T2: What do you think the turtle's problem is?
C11: S/he can't go her/his home (second activity).

T3: What is the problem of the parrot today (When the child draws her plan, the teacher goes to her and quietly asks)?
C12: Carrying the cake.
T3: What happened when the parrot moved the cake?
C12: S/he needs a car, but the car is broken (fifth activity).

S1.2: Reviews her/his prior knowledge about the problem.

T2: Have you ever crossed a bridge before?
C11: Teacher, we crossed the bridge on my way to my grandmother.
T2: Where did you cross?

C11: Over the sea.
T2: Was it a very long bridge?
C11: No, no, it's where cars go (second activity).
T2: How do you get to a high place?
C12: Through the elevator (third activity).
T2: The elevator is taking us up, doesn't it?
C10: Yes, with the pulleys.
T2: Yes, the elevator works with the pulleys (third activity).

P11: What could be pulling the elevator up?
C11: A button.
P11: A button? How a button can pull the elevator?
C11: The ropes pull the elevator. There's ropes underneath, but it doesn't seem.

S1.3: Asks questions about the problem.

T2: What happens when our world gets dirty?
C9: What happens dad (After thinking for a while)?
P9: If the air gets dirty, living things can't breathe and die (fourth activity).

S1.4: Determines the problem-solving goal.

T3: What was today's problem (When the child draws her plan, the teacher goes to her and quietly asks)?
C10: We will take the cookies…
T3: Cookies (laughing)? Where we will take the cake?
C10: To the child's house.
T3: Yes. What's in the child's house?
C10: Birthday.
T3: So, what is the parrot's problem?
C10: S/he cannot take the cake.
T3: Why?
C10: Because her/his car does not work (fifth activity).

S1.5: Identifies the constraints for solving the problem.

T2: So, how should our bridge be?
C12: High.
T2: What happens if our bridge cannot bear the weight of the turtle?
C12: It collapses.
T2: Yes, it collapses. What does that the turtle do?
C12: Turtle falls into the water (second activity).
T2: We've collected the rubbish from children's gloves. Look, there are smaller wastes inside this river. How do we collect them?
C11: We can't collect them with our hands, because we can't dip our hands in water. Disgusting.
T2: So, what should we look out for when we clean the river?
C11: Bacteria can infect us.
T2: How are bacteria transmitted to us?
C11: If we put our hands in the water.
T2: Then what was our first limitation?
C11: Taking them without putting our hands in the water.
T2: Yeah. Well, I said one more thing. How was the waste inside the river?
C11: Big and small.
T2: What kind of design would we do then?
C11: It must collect big and small ones (fourth activity) (see Figure 48).

Figure 48 Children and teacher talk about the limitations of the fourth activity problem.

S1.6: Explores available materials in respect to the limitations of the problem.

P10: Which one? Look, what's waterproof here?
The child asks his mother to use sponge, after trying to squeeze the water onto the various materials.
P10: When the sponge gets wet?
C10: Water passes.
P10: (The child taking the aluminum folio and the mother asking the child). Let's try it.
They squeeze water on the aluminum foil.
P10: What happens when I keep it straight?
C10: Get wet.
P10: What happened to the waters here?
C10: Accumulated.
P10: Yes. Let's make it inclined and try again.
C10: Water flows (see Figure 49) (first activity).

Figure 49 The child explores the materials in terms of their waterproofness.

C11: Mom, this is not waterproof (showing the foam plates).
P11: Let's try (then they tried).
P11: Look, the water didn't get under the plate, it went over it (see Figure 50).

Figure 50 Children explore the materials in terms of their waterproofness.

C11: It's soft.
C12: Yeah, it's soft. It is like slime.
C11: What's in there?
C12: It is a nylon bag (see Figure 51) (second activity).

Figure 51 Children explore the materials together.

P11: What do you think this sponge is waterproof?
C11: Mom, I don't think it's waterproof. When you're washing the dishes, then the water comes out of the sponge. Because there are holes on it (first activity).

S2: The child develops possible solution idea(s) and reflects this/these on a simple plan and model (NGSS Lead States, 2013; NRC, 2012).

S2.1: Brainstorms ideas on how materials can be used and modified.

C13: Mom, if we do like that, it will be better (while taping the tongue depressors) (second activity, the step of creating a model) (see Figure 52).

Figure 52 One of the children who brainstorm about the materials.

T2: What materials are you going to use?
C10: Napkin carton (toilet paper roll) and sticks. The garbage will stop here. Water will flow back into place.
P10: What kind of material is paper? Is it affected by water?
C10: Yes, it is affected.
T2: What do you think does it work? Think about the materials you planned to use.
C10: No.
P10: What do you think happens if it's in the water?
C10: It softens and tears (fourth activity).

P9: For example, let's say we asked your father for something from the balcony. How do we get it from the balcony?
C9: With the rope.
P9: How do we get it using the rope?
C9: We tie the rope. My dad will tie him down, then he will drop it. I will pull it up and get it.

S2.2: Brainstorms ideas on how the materials can be used together to solve the problem.

P10: Think about it. What other material can replace the towel paper roll?
C10: I found it. Sponge.
P10: How we can use the sponge?
C10: There are big sponges in there. We can put a stick in them and put them in the water.
P10: Do you think the sponge can hold the bottles in the water?

C10: No, it cannot
P10: Think about what else.
C10: Mom, I found it. There are plastic boxes there, we can use the ones.
P10: What do we do?
C10: We will remove the cover. We will stick the bowl in the water with a stick.
P10: So, how do we get the water out? What did you use to filter the tea?
C10: Filter. We will open small holes.
P10: Ok, let's draw your plan (see Figure 53) (fourth activity).

Figure 53 One of the filter ideas and its reflection on the plan.

S2.3: Produces an idea to solve the problem.

P11: We couldn't produce an idea. Is there anyone with the idea?
C13: We can do like that.
P11: How? Let's show us.
C13: You do something with a wooden stick. It stands like this (holds the paint box like a ramp).
P11: Well, does this stay on the wooden bars? Or do we need to tape it?
C13: We need to tape.
P11: Let's we draw this idea (see Figure 54) (fifth activity).

S2.4: Draws a plan, creates a physical model, and/or verbally expresses how the solution will look and act.

T2: Can you tell me about your plan?
C11: This is the parrot's house, and the parrot is here. S/he will pull her/his stuff out of here, and then the marbles will go up. And then the parrot will come into the house, and then s/he will get the thing.
T2: So, what materials do you intend to use?
C11: The rope, marbles, and marble box.
P11: And there was something there, what was that?
C11: This will pull the box (showing the pulley on the plan).
P11: A pulley.
T2: What is your second plan?
C11: There are stairs here. The parrot will go up these stairs. Then s/he will take a basket.
T2: Will the parrot carry the basket from the stairs?
C11: Yes. Then he will drop the basket, then open the door. Then s/he will come in, take the basket, and then lock the door (third activity) (see Figure 55).

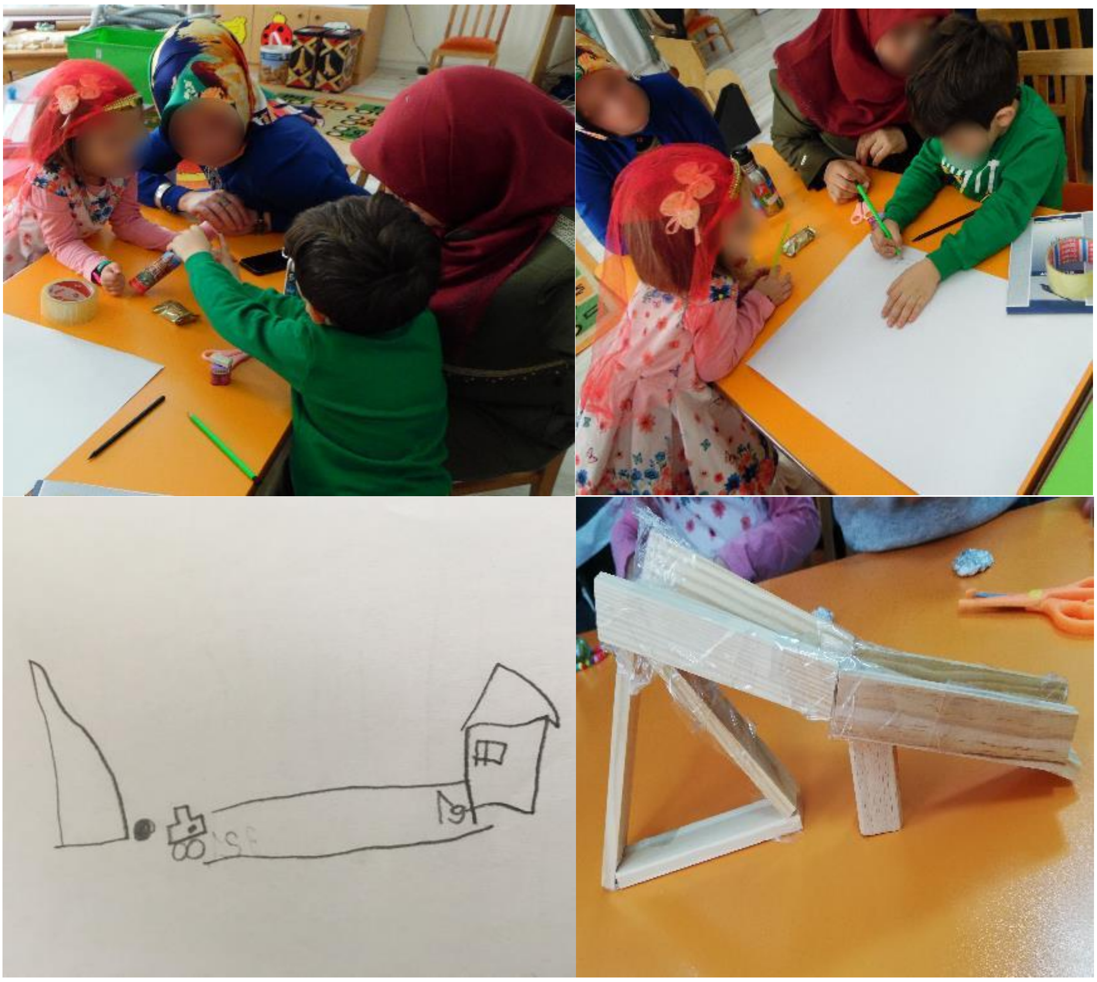

Figure 54 The groups brainstorming on the problem, the drawn plan by one of the children, and the constructed design.

Figure 55 Two different design ideas produced by one of the children to move the marbles to the parrot's house.

T2: Honey, do you have two different idea? Would you tell me the first one?
C12: These are the marbles; they are reaching the parrot's house.
T2: How they reach the parrot's house?
C12: A truck carrying the marbles.
T2: How's that truck coming home?
C12: The truck will come here and enter the window.
T2: Is it a long truck?
C12: Yes.
T2: What is your second idea?
C12: I will hook up the marbles with the rope and the parrot will pull them up (third activity) (see Figure 56).

Figure 56 The child shares the details related to her two different plans about a problem with her teacher.

S2.5: Determines the materials s/he will need while constructing a model.

P9: Should we cover the roof with something?
C9: Yes, aluminum folio (see Figure 57) (first activity).

T2: What kind of a bridge will you have?
C13: Broad.
T2: So, what materials do you intend to use?
C13: Wooden (then chose the wooden tongue depressors and long wooden sticks) (second activity).

S2.6: Tests the model s/he constructed.

C9: (After testing his model) No water dripped on the ground (see Figure 57) (first activity).

P10: What do you think? Did it get wet?
C10: Yes, it got wet, but nothing happened. Because it's steep.
T3: Do you think water get into this roof?
C10: The roof did not pass the water because it was like this (keeping the hand inclined) (first activity).

Figure 57 The child decides to cover his roof model with aluminum folio and tests the model in terms of its waterproofness.

S2.7: Produces new ideas for design based on her/his experiment on the model.

P13: What do you intend to do?
(In their first trials, the marble went down very fast and jumped down. After this trial, the child is designing a ramp with less inclination).
C13: Mom, do we tape this like that?
P11: So, what happens when you tap it?
C13: We throw the marble out of there. Mom, I'm not saying let's do it straight. We will do like that (holding blocks slightly inclined).
P11: Do you want to make a way for a marble?
C13: We leave the marble here, and here it goes (fifth activity) (see Figure 58).

Figure 58 Children produce new ideas in the light of their experiments on the model.

S3: The child constructs her/his design and tries to make it better (Cunningham, 2009; NGSS Lead States, 2013; NRC, 2012).

S3.1: Follows the plan s/he drawn or expressed to solve the problem.

P10: We need something which will pull this plastic bottle.
C10: Mom, we had drawn here (showing his plan). We need a pulley (third activity) (see Figure 59).

Figure 59 The child who drew a plan and then constructed it.

C11: (looking at her plan) One-minute dad. Okay, we will put a rod in here (looking her plan). Let's do it by looking at here, okay?
T2: You're doing the same thing you drew here?
C11: Yes, because I do it by looking at the plan (fourth activity) (see Figure 60).

Figure 60 The child and her father follow the child's plan to construct a filter.

T2: What did you planned to do?
C9: A flying elevator.
T2: I'd rather be in this elevator. Which materials do you intend to use for that?
C9: Stick, rope, and glass (see Figure 61).

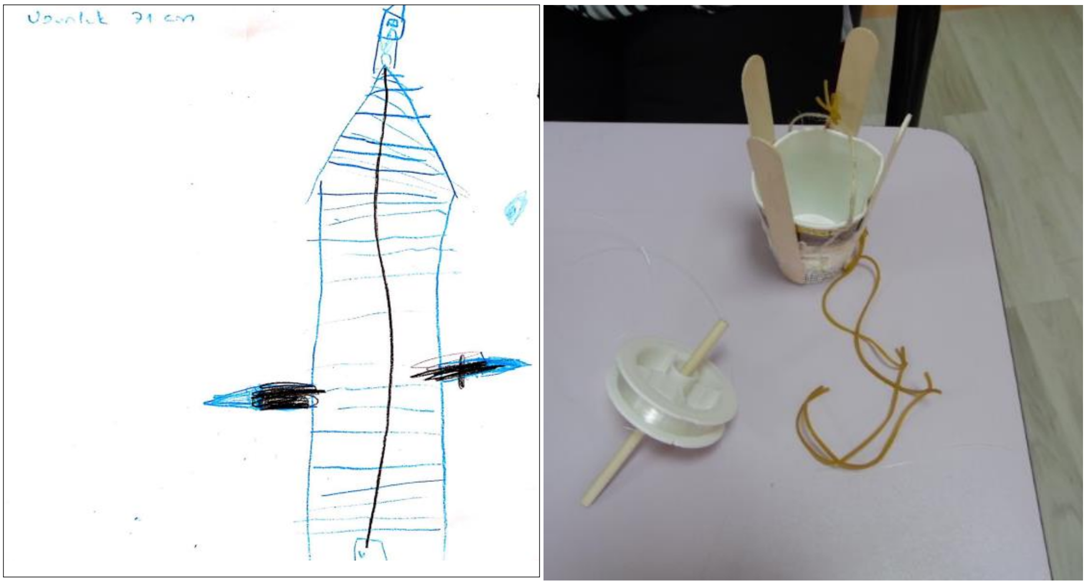

Figure 61 One of the children's elevator plan and design.

S3.2: Chooses appropriate materials for the design by taking the constraints of the problem into consideration.

C9 used plastic bottles, wooden sticks, and tape. He chose the materials himself. All the materials were appropriate for the constraints of the problem. In fact, all of them were waterproof. However, when the teacher asked why he chose these materials, he didn't answer. He only said that he added rods to the edges so that the turtle could hold while walking (researcher's field notes, second activity) (see Figure 62).

Figure 62 A bridge design that one of the children built using plastic bottles.

S3.3: Works collaboratively with her/his parents by using hands-on materials.

The mom guide C10 by means of her questions, they make real the child's ideas. They collaborate with each other. The child describes how to do it to his mother, and the mother helps him to tape the pieces. She tries to understand the child's ideas by means of questions like how you're going to do this corner (researcher's field notes, first activity).

P9: You tell me where to hold, and I will help you.
C9: Will you cut the tape from here?
P9: Where do I tape? From there?
C9: Yeah, let's tape it from that end (fourth activity).

S3.4: Constructs a design to solve the problem or improves the model s/he constructed in the previous step.

C13 tested his model, but her model did not provide the limitations. In fact, his filter did not catch the big wastes in the water. Thus, he realized that his filter was small for the bigger wastes. He created a different design by using larger plastic containers (T2, child observation form, fourth activity).

C13: Mom, look. There are holes in here. The trash will come in here (showing the inside of the plastic container. Then he goes and gets another plastic container. He says that we will keep the cover parts of plastic containers back to back and paste them like this) (see Figure 63).

Figure 63 The child creates his filter model, tests it, and decides to use different materials in his design.

S3.5: After testing her/his design, s/he decides whether the design solves the problem.

T2: (The child tested his design. When the child presses the design into the water to remove the waste from the bottom, the plastic containers are closed) What happened?
C13: Garbage's not coming.
T2: What do you say it shuts down when you press?
C13: ...
T2: Do you want to improve it?
C13: Yes (fourth activity) (see Figure 64).

Figure 64 After constructing his design, the child tries it and decides whether it works.

P11: (the child places her design on the river and her mother guides her). Is it ok?
C11: Yes, is it ok.
P11: Well, is the bridge large enough for the turtle to pass?
C11: Uhhh (tests the design and sees the bridge collapses).
P11: I want to ask you a question. Do you think this bridge carries the weight of the turtle?
C11: No, it's crushing (second activity) (see Figure 65).

Figure 65 The child tests his design in terms of its appropriateness for the constraints.

S3.6: Describes what happened when testing and what the result refers to the next version.

C10: It doesn't get into the water (He tested its design. It was difficult to immerse the plastic container in the water).
P10: It didn't sink, did it? How can we sink it?
C10: ...
P10: What does that need?
C10: Weight.
P10: What can we do with something heavy?
C10: I will fill it with something heavy.
P10: Okay, go to the stuff and see what it can be (fourth activity) (see Figure 66).

S3.7: Implements her/his improvement ideas to the solution.

C10: We will make a little stone (going to the materials and bringing the stone).
P10: Ok. How we will do?
C10: We will paste.
P10: Where we will paste? Will we wrap the stones around it?
C10: We will stick it under (fourth activity) (see Figure 66).

Figure 66 Construction and testing process of a filter design.

S3.8: Tests it again after the improvements until the design satisfies the goal.

T2: (The child tried again after adding the stones. In this version of the design, he was using both sides of the plastic container using chenille). Look, this worked. But how does it stand just a little?
C10: It's trapezoid.
T2: Do you want to improve your design?
C10: Yes.
P10: What happened dear?
C10: It did not hold in a balanced way.
P10: So, we should keep it on other sides?
C10: (after taking two more chenille and connecting them to the opposite edges) We will connect them in that way (fourth activity) (see Figure 67).

Figure 67 After implementing improvement ideas on his design, the child tests it again.

As mentioned earlier, during the implementation process, the activities were limited to three and a half hours. The children produced and applied their ideas on how to develop their designs. After examining his/her engineering notebook with each child, the researcher asked if there was a design s/he wanted to more develop among them. Findings indicated that one of the children also had improvement ideas after the implementation process. To illustrate,

I would do something for the river. You know, we had grabbed it. I put the stone in my filter, but it did not sink in the water. If there's anything sticking around the river, I'd like to take them. Besides, I would like to decorate it (C12, post-interview).

S3.9: The design complies with the limitations and requirements of the problem.

The design of the C11 provided the limits of the problem. She added holders to the edges of the design to avoid contact with dirty water. She used a larger plate to get more waste (T2, observation form, fourth activity).

S3.10: Shares the final version of the design with other children and parents.

The child (C12) shared the final version of her design by placing it on the top of the parrot's house and testing it again (T3, first activity).

T2: Can you tell us about your design?
C11: There is a box here. Then, there is a pulley in here. I tied this pulley with the rope. I inserted a stick in here. And then, when I pull this rope, the box goes up. This box will stay here like this, so the kid will come and get him.
T2: So, what did you use while designing that?
C11: This plastic container and this pulley. Then, I put the marbles here (showing inside the aluminum plate). Then, I tied the rope to here, and I taped this like that (third activity) (see Figure 68).

Figure 68 An elevator plan and design created by a child, and its presentation to other groups.

S3.11: Compares her/his initial ideas and final prototype of her/his design by pointing differences between these two conditions.

T2: You just came up with another plate. Now why do you come with this plate?
C11: Because I wanted to enlarge.
T2: Why did you enlarged?
C11: Because the garbage couldn't get into it.
T2: I understood, so you wanted to make it a little bigger (fourth activity) (see Figure 69).

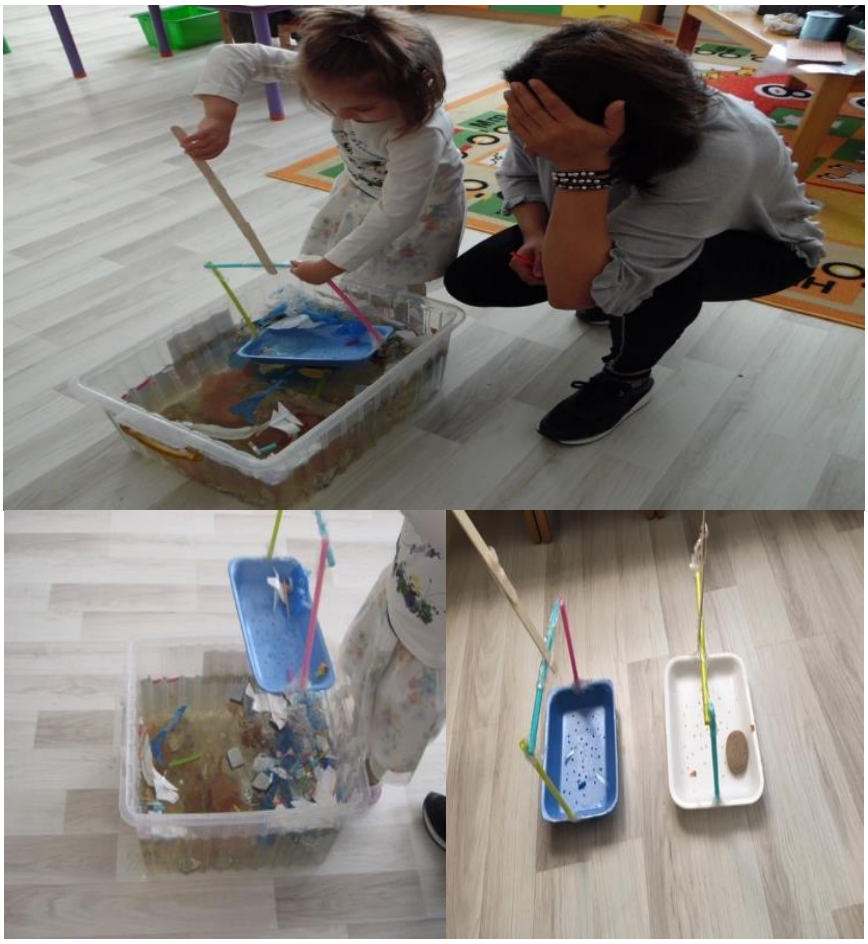

Figure 69 The child constructs her design with a larger foam plate and tries again to get more waste.

S4: The child comprehends that it is possible to solve a design problem through multiple ways (Cunningham, 2009).

S4.1: S/he explores the solutions produced by her/his peers for the engineering problem.

C10: (listens while C9 presenting his design) Mom, look at that one. We could have thought that (fourth activity).

C13: Ooo (listens excitedly and curiously while C9 testing his design) (second activity).

The child (C12) is curious about other children's designs. For example, while she is working on her design, the C12 asked C11 what her design would look like (T2, fourth activity).

S4.2: Except for what s/he designed for an engineering problem; it produces different possible solution ideas.

T2: How can we remove the marbles up? What do you intend to do?
C10: An elevator or a staircase.
T2: An elevator and a staircase. You have two ideas. Let's see which one will succeed (third activity).
T2: How we can help the turtle?
C12: By building a bridge.
T2: Do you have another idea?
C12: Yes, we can make a ship (second activity).

S5: The child comprehends that the utilized materials and the features of these materials have a critical role in engineering solutions (Cunningham, 2009).

S5.1: Explains why s/he used specific materials in her/his designs

T2: What materials did you use in your design? Can you tell us?
C10: Plastic container, rope, and stone.
T2: Why did you chose plastic container?
C10: Because it prevents from water.
T2: So, does it melt when it enters the water?
C10: No.
T2: Why did you use the stone?
C10: Because if there isn't a stone, it stays on top of the water.
T2: So why did you do these ropes so much? You've got a rope on each side. It was necessary?
C10: For equal weight.
T2: Why did you open the plastic rough hole?
C10: For the water to flow. The wastes remain here, the water again flows into the river (fourth activity)

T2: Why did you use the spoons?
C13: To hold.
T2: Why did you use two spoons? One was not enough?
C13: I tried. It happens like that (bending the container sideways).
T2: Is it becoming crooked?
C13: Yes.
T2: What happens when you use two spoons?
C13: It's straight.
T2: So, is it balanced?
C13: Yes (see Figure 70).

S5.2: Makes explanations about the properties of the materials s/he used in prior and final prototypes of the design.

The findings show that children have already made some explanations about the properties of the materials they used in these different versions when comparing the first and last versions of their designs (see the explanations related to the S3.11). Therefore, this indicator was integrated into S3.11 and was not included in the final prototype of the learning objectives and indicators of the EDCPI.

Figure 70 The child tries to take out the wastes without touching the water. He uses thin sticks but when the sticks cannot bear the weight of the container, he decides to hold the container with wooden spoons.

S6: The child utilizes her/his math related knowledge and skills (Fuson et al., 2015) to solve engineering design problems.

S6.1: Utilizes his/her knowledge and skills about the subjects of the whole number, relations, operations (Fuson et al., 2015; Moomaw, 2013) to solve the engineering problem.

Under this learning indicator, several mathematical concepts were observed. In fact, children demonstrated some skills related to key mathematical concepts such as verbal and object counting, addition, subtraction, and fractions (the concepts of half and full), and quantity (e.g. less, more, bigger, broader, taller, smaller, heavier, lighter). To illustrate,

T2: Look, there is a strainer with bigger holes. What do you think we can use this one to separate the flour and popcorn grains?
C11: The flour just passes through these huge holes.
P11: Where the car was going to? Let's draw where the car will go. What was the distance? Let's draw it.
C11: 19.
P11: Yes, it should go 19 centimeters.
P13: Draw the mechanic 19 centimeters away.
C13: Here?
P13: Yes, write 1 and 9 (The child writes the numbers 1 and 9 even though it is written in reverse).

C10: Mom, there are two sticks here. I need to take one more (first activity).
C9: One, two, three, four (counting the edges of the rectangular container he holds) (first activity).
P11: You held one of the marbles before. And then three marbles. What did you feel?
C11: Three marbles are heavier. One marble is lighter (third activity).
P9: What will you do with it? I can help you (The child tries to cut the foam globe by means of scissor).
C9: I will make half (fourth activity).
P11: We need ten pipets for these 10 ovary egg parcels.
C11: One, two, three… (they count ten pipets one by one) (first activity).
P10: Do you need tape?
C10: Yes, we will make it taller. We will extend two more (makes a handle by using tongue depressors in the model making of the fourth activity).

S6.2. Utilizes his/her knowledge and skills about geometry, spatial thinking, measurement to solve the engineering problem (Moomaw, 2013)

According to the findings, children also used their knowledge of geometrical shapes (e.g. triangle, rectangle, square, circle, semi-circle). Some examples are presented in the following excerpts.

P12: (C10 who is the other group members proposes to use rectangle wooden blocks). What is there in rectangular form?
C12: Mom, there is a rectangular among the materials. Look, should I show you? (goes to the materials and takes a block in the form of a rectangular prism and shows it to her mother) (fifth activity).

T3: How's the roof of the mosque?
C11: Semicircle.
T3: So, let's look at the roof of the opposite building. What is its shape?
C11: Triangle (first activity).

P12: (The child tries to cut the foam globe) Why are you cutting that?
C12: A semicircle. I will paste it on the top the roof.
P10: What do you think what should be the shape of our roof?
C10: Triangle.
P10: Why?
C10: Because the shape of the parrot's house is triangle (see Figure 71).

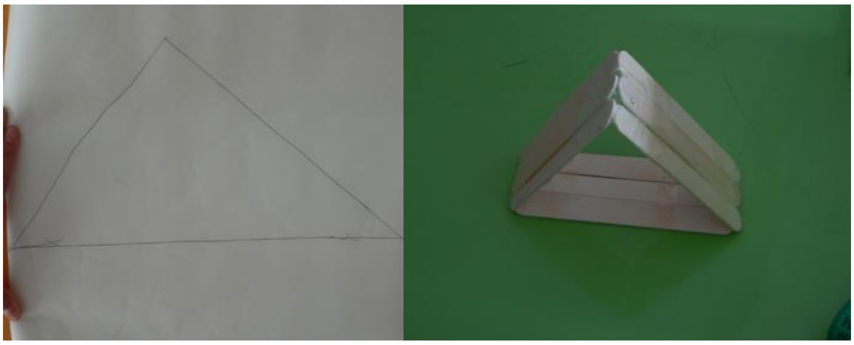

Figure 71 A two-dimensional plan and a three-dimensional model of a triangle roof design.

Children also experienced measuring with both standard and non-standard measuring instruments. In fact, their teachers reported that some children have never used a ruler or tape measure before. They experienced measuring under the guidance of their parents and create their designs by considering the data they obtained from their measurement. Observation findings revealed that, even some of them had troubles in recognizing large numbers, from the second week they began to make more independent measurements. The following excerpts exemplify these findings.

P13: How many centimeters, son?
C13: 58 (he keeps the tape measure right and he measure himself).
P13: 53 (correcting the child) (second activity).
P11: How many?
C11: ... (the child measures herself but she does not hold the tape measure correctly).
P11: Let's we measure together.
P11: How many?
C11: ... (looks at the number on the measure). 49, 50, 70.
P11: Ok. How many foam plates will you need? Let's we measure. (The child puts a foam plate on the river and mother asks) Is one enough?
C11: No.
P11: Ok. Put another one to the near of it. Is it ok?
C11: Yes (see Figure 72).

Figure 72 Children make measurement with standardized and non-standardized tools.

Children also used and developed their spatial thinking as seen in the plans drawn by them. They envisioned the problem (e.g. the turtle who cannot cross the river) and its elements (e.g. the parrot's house, the pulley systems, and the green river) and draw their plans, create their models and plans in this direction (see Figure 73).

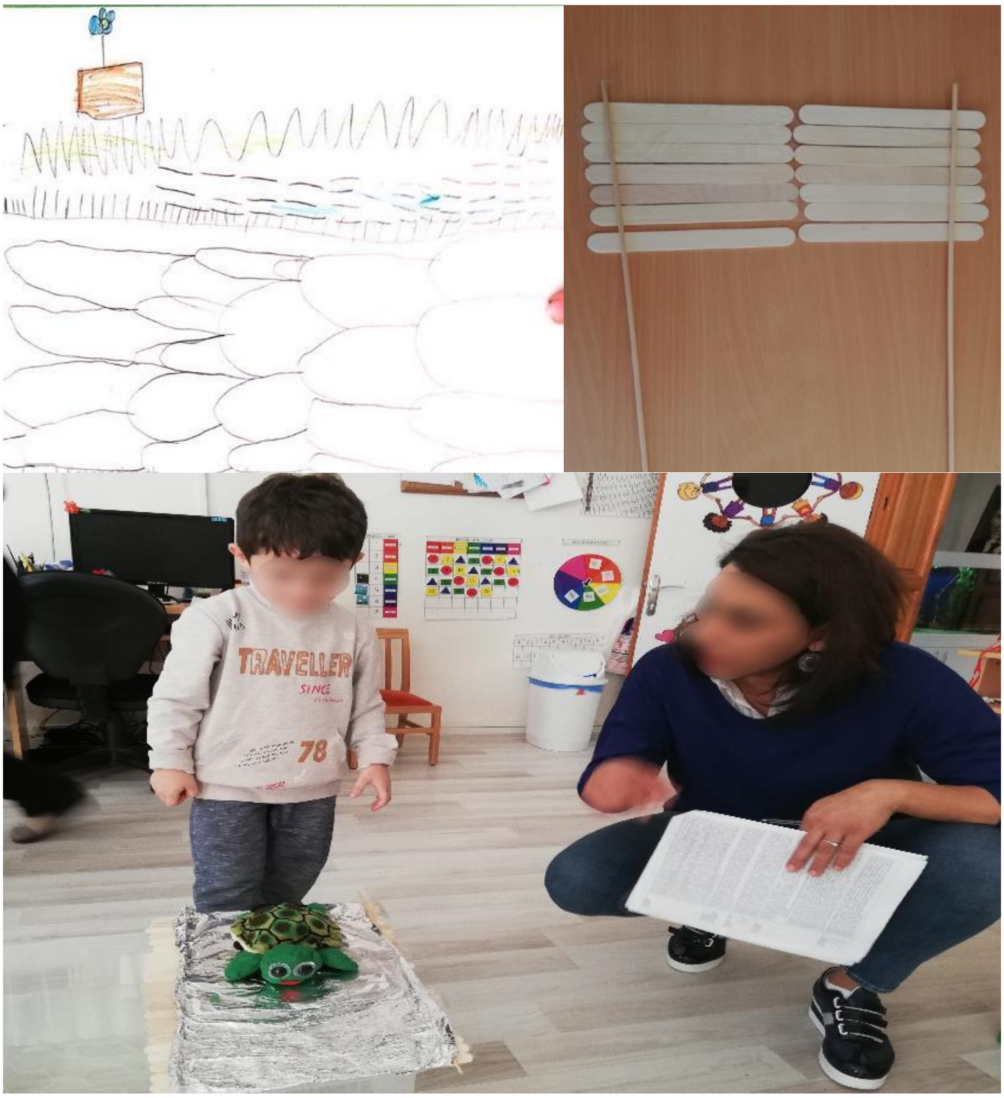

Figure 73 The plan, model, and design of a bridge which enables the turtle to cross the river.

While developing their designs, children also experienced some key spatial relations for early childhood mathematics education such as over and under (Harris & Petersen, 2019). Some examples presented in the following excerpts support this finding.

P10: Do you think the marble should force it from the top or bottom to push this block?
C10: From the top.
P10: (after trying) Where did marble hit this block?

C10: It hit this place.
P10: Is this place bottom or the top of the block?
C10: Bottom.

S7: The child applies her/his science knowledge to address an engineering problem (Cunningham, 2009).

S7.1: Utilizes her/his science related knowledge (e.g. living/nonliving things, habitats, environmental needs and specific characters of plants and animals, characteristics and changes in the natural world, weather and seasons, natural materials, scientific concepts) (Moomaw, 2013; Sylva et al., 2006) during EDP.

As in their mathematical knowledge and skills, findings revealed that EDCPI provided children with the opportunity to use and develop their science-related knowledge and skills. In all the activities, children explored different features of the materials, and they created their designs by considering different features such as type of the material and waterproofness. To illustrate,

T3: What did you use in this design? These are plastic, wooden, or sponge?
C11: Wooden (first activity) (see Figure 74).

Figure 74 The child shares her design with other groups and explains which materials she used

Some science-related concepts such as speed, incline, force was experienced by children throughout the activities. Findings revealed that especially in the fifth activity, children also used these concepts in their design process. To illustrate,

T3: Do you think that the speed of the marble will decrease or increase, when you put that block in front of the design?
C13: …

T3: Let's try. Try before you put anything in front. Then put those blocks in front of it.
P11: At what experiment did the marvel go faster?
C13: Empty.
T3: So, why did you want to put this block in front of the design?
C13: The power of this is more. The marble can push the car with power of this one (fifth activity).
T3: I only have a marble. How could I push the car with this marble? Let's think about it first.
P11: What can we do? How do we move the car with the marble?
C11: Mom, the marble has no force (before they are watching the video related rube goldberg) (fifth activity).

P11: Can I ask you something? Does the marble go faster in a flat place? Does it go faster when going up? Or does it go faster when going down the top?
C11: From up to down.
P11: Let's try. (after trying all the conditions) What was the fastest?
C11: Going down from the top.
P11: Yes, Yeah, it was faster going down the top. Then what do we do to get the marble to push the car faster?
C11: We will leave it from up to down (fifth activity).

C10: Mom, we should cut this one a little bit.
P10: Why?
C10: Look, when the roll stand like this, the marble was slow (holds the towel paper roll slightly inclined).
P10: How it become faster?
C10: When the roll is curved (holds the roll more inclined) (fifth activity).

Children also experienced the pulley system in the third activity. In fact, all of them designed different systems which operate with a simple machine. They tried the concept of force-load-fulcrum through the catapult before moving into design. During the design, they created a simple force-load-fulcrum system. Similarly, in the fourth activity, children used and improved their knowledge about the concept of pollution and its effects on our world, and habitats of some animals. Children produced their own designs to prevent water pollution. The following excerpts exemplify this finding.

T2: Water, air, soil is all very important to us, right?
C11: Yes.
T2: Why they are important? For example, why the air is important to us?
C11: For breathing.
T2: Why the soil is important?
C11: Flowers.
T2: What happened to the flowers?
C11: Flowers are taken from the soil together with the water.
T2: So, should the water be clean and healthy?
C11: Yes.
P11: Why the water is important?
C11: For the fishes.
T2: What do you think do the fishes are happy to swim in such a polluted water?
C11: No.
T2: What happens to the fish in a polluted water?
C11: They get poisoned (fourth activity, the step of think about it, try-out).
T2: What animals do you think can live in this green river?
C13: Frogs.

C12: Fishes.
C11: Crocodile.
C12: Octopus.
C11: Whale.
C12: Shark.
T2: Can such big animals live in the river? Where do such big animals like octopus, shark, whale live?
C11: In the water.
T2: Yes, they live in the water, but they live in the big waters like the sea and ocean.

T2: What people and all other living things need to live?
C10: To the breath.
T2: Yes, we need breath. While breathing, we need to draw a clean, oxygenated air in us, right? Can we breathe comfortably in such an atmosphere (shows the visuals)?
C10: No. If there were no trees, it would be like this (fourth activity, the step of think about it, try-out).

Table 35 shows the scores obtained by the engineering skills sub-dimension of the observation form for each activity. The scores in the table below are the average scores obtained from the observation forms filled out separately by the teacher and the researcher. The children were evaluated according to these average scores as emerging (0-10 points), proficient (10-20 points), and advanced (20-30 points) in terms of engineering skills. As seen in the table, throughout the first four activities, skill points of the four of the children increased each week compared to the previous week and all children exhibited engineering skills at least proficient level. On the other hand, the fifth activity was based on the collaboration of one or more parent-child groups and production of common solution design to the problem. Therefore, some children's interactions with group members were less than their interactions with their parents in other weeks. The reason for the fall in the scores of the last activity may be the reduction of the children's expressions in a crowded group. In addition, it was observed that two of the children behaved timidly while responding to the teachers' questions and explaining their designs, while other three children expressed themselves freely. Even though they offered effective solutions to the problems and created appropriate designs accordingly, these two children mostly chose to remain silent during the discussions in the instruction parts of the activities and presentation of their designs. This made it difficult for observers to understand these children's thinking in the design process.

Table 35

Learning activities and scores obtained by children from the skills dimension

Child ID	*1st activity*	*2nd activity*	*3rd activity*	*4th activity*	*5th activity*
C9	16.5	18.5	21	15	17.5
C10	18	Not attended	23	26.5	21
C11	13.5	22.5	23.5	26.5	22
C12	12.5	17.5	17	18	16
C13	11	21	Not attended	24.5	22.5

4.1.4.1.3 Children's Dispositions

Dispositions were defined as another dimension of learning in this study. In this regard, five different thinking ways focused on as dispositions in early engineering, and a different way of thinking was investigated in each activity. As mentioned earlier, children were evaluated by both the teacher and the researcher through observation forms. Therefore, in order to find out which indicators are displayed more in the dispositions dimension, firstly, how many children exhibited each of the indicators was calculated by means of observation forms that are filled out independently by the researcher and the teacher. Then, the obtained value was divided to the twice of the child number attended that week's activity. To be more specific, for example, the teacher observed the first indicator in three children, and the researcher observed in two children. The average value (Mean) for this indicator (five) was calculated by summing these two values and dividing them to twice the number of children (eight).

The first activity focused on curious thinking. Findings reflected that the first indicator was mostly observed indicator, while the second one was the seventh indicator. In other words, children showed an interest in learning new knowledge and obtaining new experiences, and they made observations and asked questions related to their observations. On the other hand, the sixth indicator for the use of different sources to find answers to questions was not observed for any child (see Table 36).

Table 36

Indicators of the curious thinking skill and examples from the study

Indicators of curious thinking	*Mean (M)*	*Examples from the study*
Shows interest in learning new things and trying new experiences.	0,9	The child seems to be focused and eager when listening to the story and thinking about the questions the teacher asks (for C13, researcher).
Makes observations and pose questions about observable situations.	0,8	Children squeeze the water onto the roof covered with fabric. The child looks through the door of the parrot's house and shares his/her observations with other children (for C11, researcher).
Becomes increasingly independent in his/her selections.	0,6	After a certain period, she adapted to the environment and made independent choices and moved forward with solutions (for C9, teacher).
Shows a willingness to learn various topics and ideas.	0,6	The child questions her/his parent's suggestion and tries to understand her/his logic (Mom, why are we gluing them side by side?) (for C10, researcher).
Poses questions to obtain information.	0,4	The child produces ideas on a subject and asks her/his parents for the correctness of her/his idea (Mom, if there was a roof of paper, the rain would have pierced the roof, wouldn't it?) (for C10, researcher).

Table 36

(continued)

Plans and carries out investigations utilizing simple equipment.	0,4	The child talks about a research that s/he plans to do at home about a situation s/he observed in the classroom (Mom, I will show you when we go home. I will get a paper, and I will squeeze it) (for C11, researcher).
Investigates and finds out the ways to produce solutions to the problems.	0,2	In case of a problem situation, he / she asks questions to learn his / her parents' opinion (What, the real roof? Mom, we can't make the real roof. How do you think we do?) (for C10, researcher).
Benefits from various resources to explore answers to questions.	0	_

In the second activity, the focus was persistent thinking. As seen in the Table 37, all the participant children designed and built a solution to the turtle's problem and they tried their models and designs several times until they reach a successful result. Similarly, all children created a plan to solve the problem, but one did not follow the plan and applied a different design idea than in the plan. Findings also revealed that none of the children seek help from their parent or teacher when they had a trouble in the design process.

Table 37

Indicators of the persistent thinking skill and examples from the study

Indicators of persistent thinking	***M***	***Examples from the study***
Makes many trials until s/he reaches success.	1	The child continued design after checking several times that the length of the bridge was not enough and that the turtle fit into the blind (for C13, teacher).
Design and carries out a plan to solve a problem.	0,75	The child planned a design including the materials to be used to pass the turtle across the river (I will use plastic bottles, and sticks. There will be pet bottles in the middle. I will paste the sticks, so the turtle doesn't fall) (for C9, researcher).
Continues to plan and pursue her/his aim until s/he reaches it.	0,75	Her design did not provide some limitations, but the child was aware of the problem and had plans to improve it (I will add these plates and then I will remove these decorations. Thus, the turtle will fit into the bridge) (for C11, researcher).
In spite of redirects or divisions, s/he can collect her/his attention for a long time in the design process.	0,5	Despite her/his parent's interventions, the child worked focused throughout the EDP (for C9, researcher).
Tests his / her solution and makes changes on the design / model according to the test results.	0,5	The child tested his model and saw that the bridge was not suitable for its width, then expanded the model by adding wooden sticks to the sides (for c13, researcher).
Appeals for help when s/he encounters a problem.	0	_

The focus of the third week was the flexible thinking and children were asked to produce more than one idea to the parrot's problem. Findings revealed that all the children represented their ideas by means of their plans and models before implementing it. In a similar vein, all the children produced more than one solution ideas to the parrot's problem and tried one of these different solution ideas. However, none of the children consulted different resources to solve the problem (see Table 38).

Table 38

Indicators of the flexible thinking skill and examples from the study

Indicators of flexible thinking	***M***	***Examples from the study***
Suggests different ways of solving a problem.	1	She created a model by creating a ramp with shoehorns. Firstly, she tried this model and then tried to carry the marbles with a pulley system (for C12, researcher).
Represents solution idea by means of a sketch, a model, or verbal expression before trying it.	1	The child represented the idea of both a flying elevator and pulling up the marbles with a basket through the plan and the model (for C9, researcher).
While trying to solve a problem, s/he exhibits imagination, inventiveness, and the ability to adapt to new situations.	0,75	The child is adapting to the environment, participant and related. He also exhibits inventiveness (for C10, teacher).
Observes and inspires other people's ways of solving problems.	0,75	The child observed her friend as she experimented. Thus, she used the idea of adding a pulley to the design and a rod in the middle of it (for C12, the teacher).
S/he is open to the opinions and suggestions of parents or peers.	0,75	The child considered her mother's improvement idea and implemented it (We tried that, but our basket turned sideways, didn't it, girl. Do you think we can tie a knot at the top of the basket or tape it, dear?) (for C11, researcher).
Adapts to new people and situations through minimal assistance.	0,5	The child can express herself freely in the community, and when she needs it, she can communicate and communicate with others comfortably (for C11, researcher).
Solves problems without being obliged to try all the possibilities.	0,5	The child reached a solution with the first design idea without having to try the second solution (the idea of the ladder) (for C11, researcher).
Implements her/his ideas to the new situations.	0,5	The child failed in his model, but he developed a new system by developing the idea he used in his model (for C10, researcher).
When s/he fails during trials, s/he focuses on developing her/his current design instead of making a new one.	0,25	In their first trial, the aluminum container they put on the marbles turned to the side. Instead of trying another material, they focused on preventing the side rotation of this container (for C11, researcher).
Thinks on the problems by considering the various possibilities and analyzing the results.	0,25	The child thought about the possibilities of solving the problem. For example, he thought of the possibility of rolling marbles and put them in a deep glass (for C9, teacher).
Uses different sources (e.g. books, images, videos) to solve the problem.	0	_

The fourth activity focused on children's reflective thinking. Findings indicated that all children documented their thinking ways by means of their plans and model. They also reflected their experiences and the rationale underlying their decisions during the design process while they share their design process with other groups. Other mostly observed indicators were talking with their parents or teachers about their experiences in the design process, remembering and ordering their experiences obtained EDP via their parents or teacher's support, and applying the knowledge of daily life to the new situations. On the other hand, the indicator regarding supporting the thinking with evidence was observed by neither researcher nor teacher (see Table 39).

Table 39

Indicators of the reflective thinking skill and examples from the study

Indicators of reflective thinking	***M***	***Examples from the study***
Documents his/her experiences and thoughts.	1	C11 made a presentation reflecting her design idea and experiences. She said "I thought to combine these two things (foam plates), then I wanted to make holes on them. Then I added pipets and sticks to hold it."
Talks about his/her experiences to evaluate and understand them.	0,6	After C12 tried her design, the teacher asked her what happened. She said she could not take all of the waste. Later, the teacher noticed that the towel paper used in the design was getting wet and heavier. "Can you move comfortably?" the teacher asked. The child said, "No, because it is heavy."
When support is provided, s/he remembers her/his personal experiences and their sequence.	0,6	While C10 sharing his design with other groups, he reviewed his design process. The teacher asked some questions to the child to guide his review. He said, "I used a plastic container, rope (chenille), and stone. I used the stone because the container remains on the surface of the water without stone."
Uses her/his knowledge of daily experiences in the new context.	0,6	In his first testing, the plastic container he used remained on the surface of the water. When the mother asked how to sink the container into the water, C10 said that they needed something heavy. Later, he chose to move through the materials and told his mother "we will make a little stone."
Establishes theories based on experience with regard to what might happen.	0,4	C13 concluded that he should add wooden spoons to both opposite sides of the plastic container after a variety of trials. When the teacher asked him why he used two spoons, he said "I tried but it happened like that (holding the container sideways inclined)." The teacher asked him what happened when he used two spoons, he said "It's straight."
Supports her/his thoughts with evidence.	0	_

Finally, the fifth learning activity was related to the collaborative thinking. As mentioned earlier, in this activity, it is aimed that the parent-child groups will work in cooperation with different parent-child groups. In this respect, two different groups were formed one of which included two parent-child groups and the other one included three parent-child groups. Table 40 presents the indicators of collaborative thinking which was the focus of the last activity and some examples observed in the try-out study. According to the findings, the most frequently observed indicators were to be aware of that others have different feelings and ideas about a situation and to await her/his turn while working on the task. However, recognizing other's basic emotional reactions and the underlying reasons of them and showing concern about other people's feelings were not observed throughout the activity.

Table 40

Indicators of the collaborative thinking skill and examples from the study

Indicators of collaborative thinking	*M*	*Examples from the study*
Recognizes and acknowledges that other people's feelings and thoughts related to a situation might differ from his/her own ones.	0,8	C11 listened her friends' ideas and were eager to implement these ideas together.
Waits for her/his turn while working a task.	0,8	In the task sharing, C9 was assigned the task of taping the pieces. He worked in coordination with his friends at the point of doing his task and waited for the order during the trials.
Interacts with her/his parents and peers in the group to plan, coordinate roles, and cooperate on the task.	0,7	In the task sharing, C13 was assigned the task of holding the pieces. He said C9, "Could you tape here?"
Communicates her/his thoughts about a task to parents and her/his peers.	0,5	"Mom, we should put something in front of it" he said to his mother. The mother said him to tell this idea to his peers. The child said another friend in the same group "Do you think we should do that?" (puts a wooden block in front of the design they create and shows his friend).
Negotiates with the group members to resolve conflicts about on a task.	0,1	In order to avoid conflict during the trials, C11 put the trial into a certain order. She said her friends, "Now it is your turn" or "Now, you will try."
Understands group members' basic emotional reactions and their reasons.	0	-
Shows interest in others' feelings.	0	-

4.1.4.1.4 Children's Engineering-related Feelings

The last dimension of learning in the curriculum was feelings. Within this dimension, there were six learning objectives, on the other hand, findings on the sixth objective were obtained through interviews carried out with children. Therefore, within the feelings dimension, the observation form was designed as including first five learning objectives and eight indicators. In addition, through the observation form, it was also aimed to obtain findings regarding the negative feelings possible to observe during EDP. In this regard, three negative feelings (NF1, NF2, NF3) and five indicators within these negative feelings were involved in the observation form (see Table 41). Therefore, the evaluation was made independent for positive and negative feelings.

According to the findings, children experienced mostly positive feelings through the EDCPI. The most observed positive feeling was the happiness to work with open-ended materials during the design process. In fact, children were satisfied to create designs with open-ended materials and excited to explore them. The following excerpts provide evidence for this finding.

Teacher, can we start (chooses the materials she needs and no sooner than sits down) (C11, first activity, try-out)?

C9 chose the materials with a great care. I think he is happy to design with open-ended materials because he tried hard, did not give up. I think he would have left it if he wasn't pleased (T2, fourth activity).

Findings regarding the feelings also reflected that children were enthusiastic and willing to participate in engineering-related learning activities. The following excerpts exemplify this finding.

T2: Now would you like to be an engineer again and make a bridge for my friend turtle?
C12: Yeeesss (laughing and yelling excitedly) (second activity, try-out).

Mom, it's fun to do (while testing her design) (C11, third activity).

C11: Teacher, are we going to paint the roofs? (during the planning step)
T3: No. Now we will make a roof with the materials here.
P11: Do you want to do it?
C11: Yes (excitedly) (first activity).

It is very fun (while testing her design) (C12, first activity).

Similarly, in the interviews conducted after the intervention, all the children stated that there was nothing which made themselves upset in the activities and they had fun doing their designs. Two of the children stated that they had mostly fun while designing the bridge. One of the remaining three children reported that he mostly liked to design filter and the other one reported that he liked to design a marble carrier. To illustrate,

R: We remembered what we have done so far by looking at your engineering notebook. Which one of you had the most fun among them?
C10: Make the elevator from the chips box (post-interview).

R: We remembered what we have done so far by looking at your engineering notebook. Which one of you had the most fun among them?
C9: I liked what I did with my father because it was more beautiful, we collected the garbage in the river (post-interview).

Table 41

Learning objectives of the EDCPI in the feelings dimension

Objectives	***Indicators***	***Frequency (from first to fifth activity)***					***Total (f)***
F1: The child likes to work as an engineer	S/he appears enthusiastic to participate in engineering activities.	4	3	3	5	4	19
	The child participates in activities without being distracted and distracted.	3	3	1	3	1	11
F2: The child likes to help people or characters who need has a problem.	The child is interested in the problems of the parrot and his/her friends.	2	4	3	4	4	17
	The child seems happy to produce solutions to the problems presented to him/her.	4	4	3	4	2	17
F3: The child is pleasured by work with her/his parent.	The child seems happy to experience the EDP with his/her parent(s).	3	4	3	4	4	18
F4: The child is pleasured by use open-ended materials in engineering activities.	The child seems pleased to construct designs with open-ended materials.	5	4	4	5	5	23
	The child is excited while discovering open-ended materials for using in engineering design activities.	5	3	3	4	5	20
F5: The child is proud of himself/herself and his/her parent because they create a design a solution to the problem offered to them.	S/he seems happy with her/his success while presenting her/his design and telling about her/his engineering process to other groups.	4	3	3	3	3	16
Negative Feeling (NF1): The child appears bored of activity.	S/he says that s/he wants to go home or gets bored while the activity is in progress.	0	0	0	0	0	0
	Leave the activity and engage with other things.	2	1	1	1	3	8
NF2: Indicates disappointment due to failure.	S/he seems frustrated when s/he and her/his parent(s) fail to resolve the problem presented to them.	2	0	1	0	0	3
NF3: He seems disgruntled to work with open-ended materials.	Expresses that s/he does not want to use the open-ended materials that are offered to make designs during the activity.	0	0	0	0	0	0
	S/he expresses her/his desire to use other materials to replace the open-ended materials presented to them.	0	0	0	0	0	0

In addition to the designs they built during the implementation process, the children expressed that they would like to perform engineering later. Designing a tool to rebuild the parrot's home, aligning and toppling dominos again and again, and designing a home were some of their future design ideas.

R: Well, what would you have designed if you were to design something other than what we did?
C12: I would want to do something to rebuild it if Kırt Kırt's house was destroyed.

R: Well, we looked at your engineering notebook. You've designed a lot of things. If we had a little more time, what would you want to design?
C11: A home.
R: What would be a home, what would you use?
C11: A little glass and wooden bars and a little thinner wooden bar, but I will make the roof with the finest things.

Children also appeared happy to experience the design process with their parents. Interviews conducted with children after the intervention also supported this finding. In fact, all the children reported that they were satisfied to perform activities with their parents. Four of the children stated that they had no disagreement with their parents during the activities. One child stated that they had different ideas at the last activity with his mother and he applied his own opinion. The child expressed himself in the following way.

R: Was there a time when you couldn't agree with your mother in doing these activities?
C13: We just disagreed on taking the car with the marble. I didn't do what my mother said. I made my own idea.

Children also were pleased to the presentation of some engineering challenges to them through the puppets and to solve the problems of these characters through their design. In fact, during the first and second activities, they gave unanimous names to the puppets (Kırt kırt and Tosbiş), and they enthusiastically seek for solution to the problems of these characters. To illustrate,

I decorated this roof for the Kırt kırt (C11, first activity).

T3: Who did you design this bridge for?
C9: It is for Tosbiş (second activity).
T2: Hi children. I am very sad today (the teacher makes the parrot puppet speak).
C11: Why?
T2: Because… (third activity).

Mom, we will be more successful (C10, creating the model, third activity).

Findings also indicated that children were happy to with their success while they were sharing their designs with other groups. Especially, while they were testing their designs in front of other groups and saw that their design was solving the problem, they seemed so happy and proud of their success. Some children express their feelings verbally, some express their feelings with body language. The following excepts provide evidence for this finding.

> *While sharing with other groups, C10 tries his design again. Meanwhile, some of the other children say "Oooo." C10 is looking at them and smiling (third activity, researcher's field notes).*
>
> *It works (looks at her dad in a happy expression) (C11, fourth activity).*
>
> *The car went in (after a number of trials they achieved to bring the car to the repair shop and the child says excitedly) (C13, fifth activity).*
>
> *T3: Has water entered (squeezes water to the C13's roof design and tries it).*
>
> *C13: No, it has not entered (he looks inside the door of the parrot's house and smiling) (first activity).*

In addition to these five learning objectives observed throughout the implementation process, EDCPI included a sixth feeling related learning objective which determined through the pre-and post-interviews. In this learning objective, the focus was on whether children see engineering as a potential career area. Before the intervention, when the participant children were asked what profession they wanted to do, each gave different answers. However, there was no engineering among these answers. Similarly, in the interview after the application, when the children were asked what profession they wanted to do in the future, various answers were obtained. Only one of the children said that he wanted to be an engineer. The findings showed that children's ideas about their future career areas changed in a short time. Indeed, three of the children changed their minds about what they wanted to be in the future, and only one of them gave the same answer in both interviews. In addition, after the implementation, one of the children did not respond when she was asked what she wanted to be. These findings indicated that children's career plans could change in a short time, and that it was possible for them to see engineering as a career area. Table 42 presents the responses of the children to the question of what profession they want to perform in the future.

Table 42

Findings related to the ninth objective of the feelings dimension

F9: The child considers engineering as a possible career	***Child ID***	***Pre-interview***	***Post-interview***
• The child says that s/he can be an engineer when asked about which profession s/he want to choose in the future.	C9	Police	Engineer
	C10	Racing driver	Racing driver
	C11	Mother	-
	C12	Teacher	Veterinary
	C13	Doctor	Police

Children also experienced some negative feelings throughout the implementation process. In fact, their negative feelings were related to their distraction and their frustration due to the failure. First, findings indicated that children sometimes left the activity and engaged with other things. For this reason, parents had to warn their children from time to time. This was generally seen in the same children every week. The following excerpts reflect this finding.

Will you please just leave him. The teacher is telling something (P9, fourth activity).

Mom, can I play with your phone (C9, third activity)?

C12 left the design process to her mother and began to paint tongue depressors (first activity, researcher's field notes)

Another negative emotion experienced by the children was the frustration stemmed from the model or the design that did not produce a successful result at the testing step. As a matter of fact, the children experimented repeatedly until they were able to find solutions to the problem and provide limitations, and some of these trials resulted in failure. To illustrate,

It is not what I wanted. Water got in it (the towel paper rolls in his roof design get wet and he says her mother in an upset expression) (C13, first activity) (see Figure 75).

When he did something wrong, I saw him feeling so upset (P13, parent journal, first activity).

Figure 75 The child tests his roof model and sees that paper rolls get wet.

C10: Mom, that happened ridiculous.
P10: It's okay. It can be ridiculous; it doesn't have to end (talks about their roof design) (first activity) (see Figure 76).

Figure 76 The child has some troubles while tries to cover his roof design on the parrot's house.

The findings revealed that as children experience the EDP, they started to find out where the error was and to improve their designs, instead of experiencing frustration. Because the EDP was a process that gave them the opportunity to try and develop them several times, and the children were more focused on testing and improving their designs. For example, in the second activity, the bridge design of the two children did not satisfy some limitations. These two children tested one last time sharing their designs with other groups. One of the bridges fell into the container representing the river since it could not carry the turtle. The other bridge was not wide to be crossed by the turtle. Both children produced ideas to develop their designs rather than frustration. Similarly, in the last activity, both groups tested and improved their models and designs over and over. One of the groups didn't manage to get the car to the mechanic, but they didn't seem to be frustrated and they wanted to try it continuously. To support this finding, the quotations from both afore mentioned activities are given below.

T2: Let's ask C11 and C12. Your bridges need to be improved a bit more. C11, what do you want to do to improve this bridge?
C11: I'll add these (holds the foam plates in her hands towards the sides of her design).
T2: What kind of a bridge will it be when they're attached to them?
C11: One and two. I will add them sideways. After that, I will get the decorations out of here.
T2: Then will the turtle fit in here?
C11: It will fit (see Figure 77).

Figure 77 The child tests her bridge design and shares her ideas with her teacher

T2: How do you want to improve this bridge?
C12: I will paste these (shows the plastic covers) and Tosbiş will cross.
T2: But if you put also them, wouldn't the bridge be a little heavier?
C12: I will take these ones (shows the towel paper rolls) and I will paste these ones (plastic covers) (the step of sharing, second activity) (see Figure 78).

Figure 78 The child is testing the bridge design and the bridge cannot bear the weight of the turtle.

4.1.4.2 Possible Contributions of EDCPI to the Parents

The EDCPI provided valuable contributions to not only preschool children but also their parents. It is possible to examine these contributions as parallel with the learning objectives determined for parents to be reached. To that end, pre-and-post interview findings obtained from parents participated in the micro-evaluation and try-out study were presented comparatively for each learning objective. The first objective was related to parents' understanding of what engineering is and what engineers do. Pre-interview data revealed that before the intervention parents defined engineering as producing something new, inspecting the produced technologies, making inventions, and designing. In this regard, they reported that engineers engaged in doing projects, designing new things, providing the functionality of the design. To illustrate,

> *Engineering is to produce new things. In fact, it is related to the field but in general, I can define it as producing new things in the working field or designing the existing one in a better way (P11, pre-interview, try-out).*

> *Constructing something, making new inventions, and finding new ideas. What he produces makes life easier for those who use it and pay for it (P6, pre-interview, micro-evaluation).*

> *An engineer checks the work of working people. It checks whether it is done in accordance with the conditions and gives approval if appropriate (P2, pre-interview, micro-evaluation).*

> *An engineer decides what to do next. They have a variety of branches, but they all make the final decision, or decide whether the feasibility report is appropriate or not (P4, pre-interview, micro-evaluation).*

> *Doing the mainframe of the designs in the being worked field. So, providing the functionality of the design according to the field. For example, a civil engineer thinks that how construction can be better in terms of both usefulness and durableness. (P13, pre-interview, try-out).*

> *Depends on the department but the civil engineer builds constructions by producing new ideas. Similarly, the chemical engineer can reveal something new about the food or s/he finds solutions to problems, even if s/he doesn't produce anything (P9, pre-interview, try-out).*

> *Apart from these definitions, one of the parents was an electrical engineer and defined the engineering in terms of its labor and economic advantages. According to this parent, engineering is;*

> *A branch that aims to make a job in the most economical and efficient way (P1, pre-interview, micro-evaluation).*

As seen in the explanations above, only two of the parents addressed the problem solving, which is the ultimate goal of engineering. On the other hand, post-interview findings indicated that parents had a more comprehensive understanding of engineering. In fact, their definitions after the intervention also included solving daily life problems and making people's life easier. These definitions are parallel to the definition of engineering in the literature

(Katehi et al., 2009; NGSS, 2010; Park et al., 2018). Therefore, this finding revealed that this learning objective was reached by parents through the EDCPI. The following examples exemplify how parents define engineering.

> *I can define engineering as making people's lives easier, designing solutions to problems (P10, post-interview, try-out).*

> *Engineers solve the problem in the shortest and most economical way (P1, post-interview, micro-evaluation).*

> *The engineer creates projects and makes inventions in order to make life easier for people (P12, post-interview, try-out).*

> *Engineers contribute to the construction of everything and think about how we can deal a work more easily… I think it produces new things to solve existing problems. It doesn't just have to be a problem, but it can also make things run smoother (P13, post-interview, try-out).*

> *Engineering to find a solution to a problem in various ways (P2, post-interview, micro-evaluation).*

> *The person who thinks, wants, implements and realizes what he thinks to eliminate this problem in the face of a problem. To make our lives easier (P8, post-interview, micro-evaluation).*

> *If we define it through activities we do with children, we can say that engineering makes people's lives easier (P5, post-interview, micro-evaluation).*

> *Engineers invent something, the inventor makes. S/he thinks things that make people's lives easier, s/he invents them, s/he produces them. So, engineering is to invent and produce (P6, post-interview, micro-evaluation).*

The second learning objective is related to gaining an understanding of the effects of engineering on people's lives. Pre-interviews conducted with parents revelated that parents were aware of both positive and negative effects of engineering to our life. All parents have stated that engineering is effective in almost every aspect of our lives, from the production of the fat we use in our meals, to guiding the farmers in the cultivation of crops. One of the parents stated that the engineering products not only affect our daily lives, but also contribute to our national development. Some examples provided by parents to the positive effects of engineering are presented below.

> *For example, my husband is an electronic engineer, but he works in another institution. He is an expert in agriculture and rural development. One day, if he can do his own profession, he wants to realize his biggest dream, building solar panels. The energy to be obtained from such a solar energy panel can be converted into electricity and it can contribute to our country in terms of production of our own energy (P12, pre-interview, try-out).*

> *The wind power plants, airplanes and vehicles produced by engineers make our life easier (P6, pre-interview, micro-evaluation).*

> *We can even call it the most effective. For example, gene engineering or chemical engineering play a role in the treatment of diseases. In other words, we use engineering products from health to social life, from computers to buildings (P11, pre-interview, try-out).*

> *For example, it is important how meticulous the engineer works when building a building. The engineer makes the control process here. If the engineer properly checks the building and makes its inspection, it will be a positive feedback to people (P3, pre-interview, micro-evaluation).*

> *Let me give you an example on my own work. We make drinking water networks of cities, we make sewerage networks, we make sewage treatment plants, they are directly related to public health. Of course, I am interested in the electrical parts of these works, and there are also engineers who work in different branches such as construction, geology and so on (P1, pre-interview, micro-evaluation).*

In addition to positive impacts, parents reported that engineering could adversely affect our lives. According to the parents, this negative impact may be directly related to engineering products or may also be caused by the misuse of these engineering products. Besides, two parents attributed this situation to the engineers who did not do their job well. To illustrate,

> *Their designs may adversely affect people's lives. For example, we say technology is developing. Let's talk about computer engineering. Our children are very dependent on technology when they develop a program. I try to restrict as much as I can, but she nags at me (P12, pre-interview, try-out).*

> *For example, the foundation of the building must be appropriate to the size, diameter or location of the building. If this foundation is not good, if the engineer does not control this well, the building collapses and affects the lives of many people (P4, pre-interview, micro-evaluation).*

> *Depending on the purpose of use, this is completely dependent on the people who use the things that are produced. For example, the social networks are something that the computer engineer produces. It can be used very nicely in an efficient way. But I work in the ministry of family and social policies. Because of the bad use of these social networks, I see that people are victimized and apply to us (P11, pre-interview, try-out)."*

> *In general, road construction work, wrong way, false bend works as a result of people experiencing negativity. For example, there had been a train accident recently, and it was said that there was an engineering fault (P10, pre-interview, try-out).*

> *For example, genetically modified organisms, products not suitable for children's health, or products called hybrid seeds are produced by engineers. They are being used badly. For example, some engineers manipulate the genes and it affects our lives negatively (P9, pre-interview, try-out).*

Post-interview findings revealed that parents had same thoughts related to effects of engineering to our life. As in pre-interview, parents reported that some engineering products, misusage of these products, and the faults done by engineers could cause negative effects. In the case of positive effects, the findings showed that parents gave examples of the positive effects of engineering from everyday life. This indicates that EDCPI increased the awareness of parents about the engineering examples in our daily lives and how they made our lives easier. To illustrate,

> *For example, everything I use in my home makes my life easier. Whether it's a food processor or a beater or a refrigerator, for example, it allows us to keep our food. There are many instances of it in our daily lives (P10, post-interview, try-out).*

> *The inventions made by the engineer make our life easier. For example, I can give lifts as an example (P9, post-interview, try-out).*

> *For example, I have understood the importance of environmental engineers in this training. I've seen the contribution of environmental engineers to environmental cleanliness, the nature of our environment and how dirty the area we live can be. The tools used in the home adversely affect our lives if not practical. We see that life is better when roads are built in buildings cars make it easier for people to live (P13, post-interview, try-out).*

The third learning objective was regarding with the parents' understanding of the importance of engineering in preschool children's education. To reveal parents' initial awareness about the existence of engineering in early years, they were asked whether they observe any behaviors of their children that remind them to the engineers. Pre-interviews findings revealed that five of the thirteen parents reported that they did not observed any engineering related behavior of their children. The remaining eight parents reported that engineering exists in their children's building-building games, in their designs they created with open-end materials, in their interests in repair tools, electrical assemblies, and the working systems. The following excerpts provide some examples of children's behavior that reminds their parents of engineering.

> *For instance, he's very interested in cars. it reminds me of mechanical engineering and electronic engineering. He is very interested in cars and curious about what kind of features they have and what's the use? His imagination is so high, he dreams cars are flying, he plays games like that. He has a tendency towards machines, engines, and mechanics (P6, pre-interview, micro-evaluation).*

> *We have a little toolkit, and my daughter is always taking her out of the closet. If a toy breaks down, if it is broken or if it changes the battery, it immediately brings the tool set and says "Mom, let's fix it." She opens the inside of the toy, opens the screw, rips it off, wears it. (P8, pre-interview, micro-evaluation).*

> *I sometimes compare my son to the civil engineer because he wants to produce farms continuously. He wants to put a lot of things from the coop to the chair in his building. He makes things like the house blocks, the wooden blocks, the car dealership, the parking lot and the hotel (P9, pre-interview, try-out).*

As illustrated in the statements above, before the intervention most parents had been aware that engineering was part of their children's daily activities. On the other hand, some of them had not aware of the existence of the engineering in their children's daily activities.

Parents were also asked what they wanted to have in the content of the engineering education that would be given to their children. They emphasized the activities that allowed their children to explore, gain firsthand experiences and make designs. In addition, one of the parents reported that such an education should provide her/his child with information about engineering profession.

> *Instead of solving problems through the books, s/he should be able to make his own decisions, to think and create something (P1, pre-interview, micro-evaluation).*

> *I wanted my child to produce new things, I wanted him to design something. I wish he had his own thought and reflected it on his drawing (P10, pre-interview, try-out).*

> *Maybe it will be simple, but it could include exploring and creating a new product from unused materials at home (P9, pre-interview, try-out).*

> *Engineering education to be given should be towards the practice. It may be related to chemistry, magnets or physics. For example, the ice slides over the water, the child can put the ice on the water and see it floats on the water. This is related to the buoyancy of water. S/he can see how the electricity is produced through the electric motor in a simple way to understand its logic (P6, pre-interview, micro-evaluation).*

> *I buy pieces of small models, you know, they are used for making ships and planes. My children like such kind of things and we build them together. According to me, engineering education can include such type of things (P13, pre-interview, try-out).*

> *I want my child to know what an engineer does. For example, my child knows that the police are protecting people, so I want my child to be well informed about engineering. My child would like to know what the engineer's duties are and what his/her place in our lives. Perhaps the engineering will attract his attention and the child will turn to this area (P2, pre-interview, micro-evaluation).*

In addition, all participating parents stated that they want engineering to be included in the curriculum implemented in their children’s classroom. According to them, engineering education can contribute their children’s viewpoint, social, motor, and cognitive development, creativity, problem-solving skills, readiness for elementary school, imagination, and self-confidence. Some of the parents also reported that their children can see the engineering as a career field through the engineering education. For all these reasons, parents believed that engineering education should start from early childhood. Their statements are exemplified in the following excerpts.

> *It changes the perspective of the child. In other words, he thinks to produce something and directs him to produce. Instead of using the ready one, he tries to do something (P6, pre-interview, micro-evaluation).*

> *I think that engineering education will be very effective in cognitive development of creativity, creative thinking and development of hand muscles. It also affects hand-eye coordination positively (P9, pre-interview, try-out).*

I think engineering education should start now because life starts from kindergarten. When the tree is old, it bends, that is, when children are younger, they perceive and perceive more quickly (P4, pre-interview, micro-evaluation).

It is useful to produce solutions to problems, can contribute to practical intelligence (P11, pre-interview, try-out).

S/he learns better in the future. When s/he goes to primary school, s/he seems to start ahead of her/his peers (P9, pre-interview, try-out).

As seen from their statements, parents had an initial knowledge about importance of engineering education in early childhood years. On the other hand, findings obtained from post-interviews revealed that EDCPI improved parents' awareness of importance of the engineering education in early childhood. In fact, as in before they participated in the implementation process, all the parents reported that they wanted to the integration of the engineering in the ECE curriculum implemented in their children's classrooms. Parents believe that engineering education provides their children with hands-on learning which was more meaningful for them rather than direct instruction. A large body of participant parents stated that they were raised in a system of education based solely on theoretical knowledge, and that they wanted their children to be educated in an educational system linked to practice and everyday life. To illustrate,

Children are already curious about everything, they have the chance to express themselves in this kind of education, they find themselves, what they want to do what they want to do in the future (P12, post-interview, try-out).

I would really like to have engineering involved in my child's class. So, preschool education is not constantly painting sticking. Okay, that kind of activities develops motor skills, but in engineering what we're doing is something different. It's like bringing back the lost imagination. In our childhood, we used to make a sieve from the can. We used to make a hole in the tin's gold with a nail. We used to crush wheat and sift the wheat through these sieves. That day they made a strainer that the child cannot even imagine how to make a hole on the plastic. But when we were in the village at that age, we were having them. And now all this has been erased. I mean, if this training is given continuously, their imagination develops a lot (P13, post-interview, try-out).

Nothing is learned only through the book, so we need to connect learning to life. I mean, every day we see examples of some concepts in our home, but when these are given in the context of a lesson and only through the books, we cannot perceive anything. We have grown with this education system. We started to understand our professions when we started working. Because we found the opportunity for putting something into practice when we started to work. The children learned both concepts there and thought of what I could do in the face of a problem. They developed their way of thinking (P10, post-interview, try-out).

According to parents, engineering education contributed their children's opportunity of exploring her/his interests and supports their analytical thinking, creativity, problem solving skills, productivity, curiosity, imagination, and motor development. Besides, parents reported that children gained an awareness about engineering products in their daily life, experienced the happiness of producing something, learned new concepts, learned not to give up, learned what is the engineering, and experienced EDP. According to them, engineering education provided their children with learning by doing and with fun.

> *Children's interests and abilities, analysis and thinking skills are changing a lot by means of engineering education (P8, post-interview, micro-evaluation).*

> *I think engineering develops mathematical thinking and analytical thinking skills, problem solving skills of the child (P12, post-interview, try-out).*

> *I think it's very useful. For example, children may have different ideas, something that might be useful to humanity. He develops his mind because he thinks things to produce. Today there are always standard toys, everything is ready in front of them. Engineering can be a different way of thinking, arousing and improving the child's desire to think, create something (P6, post-interview, micro-evaluation).*

> *Engineering is developing the child's imagination a little more. The boy saw something he didn't know or something he didn't see. For example, in moving the marbles to the parrot's nest, he saw how he could move and in what ways. Or, he saw what the bridge was like, how it should be. He learned to measure things with the meter, and to keep the scissors better while cutting something with scissors. Hand skills are also evolving, in the meantime, while doing them with imagination. I think it's a practice (P4, post-interview, micro-evaluation).*

> *It is important for the child to develop his/her creativity and develop his/her hidden abilities and learning. Because he seeks to find solutions by dealing with problems on his own, he can cope with problems, and at the same time, when he is confronted with at least one problem, he can produce multiple ideas. That's why I think it's a proper training (P9, post-interview, try-out).*

> *During this workshop, I have noticed that engineering in preschool education will add a more creative feature to children. If this education is given regularly in their classroom, children can have a more constructive and different perspective. In a family as us that has nothing to do with engineering, the child may not realize how to do different things from different materials. But if she gets this kind of training, it gives her the perspective of producing things that are very different from what we consider as unnecessary as waste material or garbage (P11, post-intervention, micro-evaluation).*

> *My son is now able to identify the engineering products he sees in his daily life. For example, electricity went off last week when it came to activity. None of the traffic lights. When I asked the teacher what the engineers were designing during the activity, my son said that they had made a traffic light. We never talked to him when the lights were designed and designed by the engineers. When he answered in the classroom, I realized that the child was able to connect the traffic light with the engine (P10, post-interview, try-out).*

> *I saw that they were happy to be doing them. My son was always happy there and always happy. In other words, the fact that he is doing something and that he makes a constant thinking gives the child a different dimension. It's called creativity (P13, post-interview, try-out).*

One of the parents pointed out that children could use their engineering-related learning in their daily life. Similarly, other parents reported that after participating this intervention, her/his child began to analyze her daily activities and establish cause and effect relationships among events. The parents expressed their idea in the following ways.

It wasn't just an engineering education. In fact, there is physics and mathematics in it. The child should do something that makes his life easier. At least, for example, when a device breaks down, the child can fix it. When he has a problem in his life, he can produce solutions. He does not have to be an engineer. I think that such skills will make his daily life easier. Because there are people who can't even use a screwdriver (P10, post-interview, try-out).

My daughter's analysis and thinking skills improved. From the first week, he began to analyze and evaluate everything. When she has done something, she has explained each step "we did it for that" and "we did it that way." She began to establish a cause and effect relationship. She talks to oneself "Look, we did this for this, I used this here, I did this, I did this like that" (P8, post-interview, micro-evaluation).

As seen in the parents' statements, parents were able to evaluate the importance of such a training for the child more comprehensively after experiencing EEE through EDCPI. During the pre-interviews conducted before the implementations, parents were also asked to define PI in education. The four parents defined PI as doing an activity with the child, and one of them described it as being aware of what was going on in the school environment and supporting the school. The following excerpts exemplifies parents' definition of PI.

I think PI is to create a project that enables to spend quality time and work together in the same environment with the child (P12, post-interview, try-out).

One of the parents attends an activity with the child. This person could be someone else who cares about that kid. For example, it could be a grandmother or grandfather. In short, it is an activity that the child and parent do together (P11, post-interview, try-out).

For parents, PI is to be known about what's going on in the school. Because sometimes the child's bag goes to home and back to the school, but the parent does not check it in any way. I think that this parent did not contribute to the education of the child, s/he only took the child to school. I mean, PI is the contribution that is made to the school by the family and to know what is being done at school (P13, post-interview, try-out).

Findings indicated that parents supported their children's education by means of home-based involvement. Their support was mostly related to purchasing educational activity books and toys for them, by making painting, reading and literacy activities with their children, by having conversation with the child, and by making the child think on what s/he observes. For example,

My son likes painting more and we do painting works together. Sometimes we do line work. We mix the dyes together and produce a new color. We produce new colors from the dough or produce something new with dough (P9, post-interview, try-out study).

We bought an activity book. Before my other child was born, we were doing activities from this book with my son. We were trying to open a page from this book and implement what kind of activity on that page (P10, post-interview, try-out study).

I bought books for him and we read them. He's already learned the concepts while doing homework with his sisters. Other than that, I'm asking questions while walking. For example, I ask why the leaves are yellow, asking questions about seasonal changes. I ask why we eat the *fruit vegetables we eat. I make her think about them. I'm getting toys together (P13, post-interview, try-out study).*

When their school-based involvement was examined, findings revealed that parents participated activities in which each parent visited classroom in different times of the year and make an activity with children in the classroom. On the other hand, two of the four parents had not participated in any PI activity conducted in the school environment. The following excerpts present some examples from school-based involvement activities implemented by participant parents were involved.

Every parent made his own wish, came to one class and made some experiments, some made cookies, some stories. We played a game about numbers as a group of two (P12, pre-interview, try-out).

We went to class together with two friends. We made the grass man put the chips in socks and we planted grass seeds in them and raised them (P10, pre-interview, try-out).

Last year we were asked to produce a Montessori toy, to bring it to the school, to introduce it to the students and to practice together (P11, pre-interview, try-out).

When their perceptions of invitations to be involved were examined, findings indicated that parents were satisfied to being invited to such a learning environment where EDCPI would be implemented. According to them, involving their children's engineering education process could enable them to explore their children's strengths and weakness and provide them with the knowledge EEE and how to support it in early childhood. For example,

A nice feeling to be invited to such a process. Of course, I liked the idea of seeing what my child could do better, what he couldn't do, whether he had a deficiency and how to guide him. Maybe there's something I can't see, but the teacher sees. It would be useful to us (P9, pre-interview, try-out).

When such an education is carried out only with the child, only the child learns. When it is done with parental support, it becomes lifelong supported. That is, if the parent participates in this training, he / she develops positive thoughts on the subject and if the child has such a tendency, he / she can support his / her child positively and what the child learn becomes more permanent (P11, pre-interview, try-out).

After the implementation of the try-out study, parents were asked again to define PI. The findings revealed that after the intervention, parents' definitions of PI were more comprehensive and included the expression of collaboration with the child and examples of engineering education. For example,

To do some activities together with the child for a purpose. This may be just like engineering education as we participated, or a play. It can be thought of as a direct education, or as an entertainment. You play parcheesi with the family and it is a PI. A speech related to the engineering, helping the child while doing homework or learning how to read and write can be *a PI. I think that every activity that is made with the child and whose foundation is education is PI. (P11, post-interview, try-out).*

PI is to support the child by asking some questions or giving instructions, not to interfere in every job of the child. We can give it a chance to experience it, to support where it's doing wrong. It's nice to see a child who can't climb to the chair do it by experience instead of putting up his foot (P13, post-interview, try-out).

PI is the active role of the parent in cooperation with the child. It can also be in a school setting, in a classroom setting, or in an environment where the family participates in the child's education. I think even a game played at home can be considered as PI. Every activity that the family is involved in, for example, doing an excavation in the garden, making an anchor with the child or planting seeds. For example, what we do the most is to deal with the garden, deal with chickens, ride a bike together, go to the cinema together. I think they're all PI (P9, post-interview, try-out).

The fifth learning objective was related to becoming aware of that parents were valued in EEE environments. Parents' statements reflected that involving in their children's engineering education through the EDCPI made parents felt valuable in such a learning environment.

It was very nice to be with my child and attend the activity there. Moreover, it really is nice to let him think or see what he thinks. Sometimes we lose this sense in the tempo of life. I saw what my child could do. For example, I was really surprised when they helped the parrot at the last activity. That was the final point for me (P13, post-interview, try-out).

Being in such an educational environment made me feel good. I even felt privileged because such things were not so frequent (P12, post-interview, try-out).

Participating such an PI activity made me feel myself so active. I mean, I never thought I'd be so effective in my child's education. This makes me happy because her/his family gives the basic education to the child. I was very happy to be able to contribute to the child's education, I was happy to teach my child something. I was happy to be able to teach something in the name of science, not just in everyday moral issues (P10, post-interview, try-out).

EDCPI also aimed at making parents learn different ways of supporting their children's learning process in engineering. To understand to what extend EDCPI contributed to parents in this matter, firstly their initial role constructions for involvement in their children's engineering education. When parents were asked how they could contribute their preschool child's engineering learning process, six of the thirteen parents who participated in micro-evaluation and try-out studies stressed that they need the teacher's guidance in the matter of what they could do. Besides, parents reported that they could support their children in engineering by guiding their children, carrying out experiments with the child, participating similar activities, providing the child with material and working area, implementing engineering in the home environment, and helping the child's homework. The following excerpts exemplify their statements.

His teacher will guide us. In the course of this guidance, we can talk to the teacher, seek advice of teacher and try to assist the child as much as we can. We can perform similar activities at home as a continuation of the education given in this workshop (P9, pre-interview, try-out).

I can guide my daughter. Maybe I can help her by providing with opportunities. I can financially support their class, because it's a public school. For engineering, perhaps a model, maybe a material which would be used, I can provide it. Other than that, maybe I can help my child where hand skills are needed (P8, pre-interview, micro-evaluation).

I don't know what I can do. You should be guided about what we will do. You should tell us. I think you should direct us (P5, pre-interview, micro-evaluation).

Some of the lessons taught at school can be given as homework. We can be asked to do this homework together at home. I try to pass on my knowledge about a homework to my child, try to guide him. I can direct him to the engineering profession (P6, pre-interview, micro-evaluation).

Findings revealed that EDCPI contributed to the parents' knowledge of different ways of contributing to their children's engineering learning. In fact, in the pre- interviews, parents had limited knowledge of ways to support their children's engineering learning, but after participating in the study, parents said that this could be done in many different manners. According to the parents, talking with the child about engineering, scaffolding him/her, providing him/her with open-ended materials, planning and performing engineering related activities at home, participating such type of workshops, giving the child the opportunity to practice trial, and appealing for him/her help in a housework might be some of these ways. Some examples are presented in the following excepts.

In such a workshop, I want her to learn by living. After that, I think we can do some more activity together at home. In doing so, we can think about what we do, how we do it, how we can do it to solve a problem. I think we can play more effective, more useful games by thinking about these points even when playing games (P8, post-interview, micro-evaluation).

I would like to send my son again if there is such activity. I'd like to help if she has a homework at home, like to tell her what it's like. For example, there is a project in my mind, we could not yet, we could not implement. I have a project in my mind in which we would design a house, a car garage, and a windmill working with the battery in the toys (P6, post-interview, micro-evaluation).

In this process, I saw that I can support my child. For example, when I can't do anything at home, I ask him for help, so he supports me. I'm giving him a boost. This study has contributed to our lives in this direction. My son thought he could repair it if the faucet was broken even when he was 3 years old. He wants to try, and he's curious (P10, post-interview, try-out).

While our child is doing a job, we can direct him with questions. In other words, it was very fun to think that the child would see things like the paper being wet, the spoon was heavy, the plastic would not sink. It was an educational at the same time. We think that children know what we know, but we need to let them experience. I saw as a mother that my child can do very nice things by trying, so I wish he continues to try also at home (P13, post-interview, try-out).

For example, my son and I can do whatever he wants to do with the items he collects. I can try help him in his way rather than lead him (P9, post-interview, try-out).

In addition to these alternative ways, one parent stressed that s/he could purchase engineering related picture books for her/his child to contribute the child's learning in engineering:

> *I have plans for what I can do. I was usually buying more fairy-tale books. Now I want to take story books like Gizmo and direct my daughter in that direction. In fact, I searched that style of books, I searched the publishing house (P12, post-interview, try-out).*

Findings also indicated that some of the parents started to put these ideas into practice. Indeed, some participant parents reported that after the implementation process, they contribute to their children's engineering learning by creating a problem scenario and designing solutions with the child and by speaking with the child about engineering. For example,

> *We went on a trip to Istanbul for a wedding. On the way, we talked with my son about whether the engineers built the bridges and roads that we saw (P10, post-interview, try-out).*

> *We've found activities she had done before. I had kept her activities, had not threw. There were a lot of recyclable materials among them. We found also an elderly aunt made of toilet paper roll, they made it in the senior citizens week. We started to think how this old aunt could go to his grandchild. My daughter started to draw a plan. She cut the wheels from toilet paper rolls, and tried to do something (P12, post-interview, try-out).*

As clearly seen in their statements, after the implementation, parents had alternative ideas about how to contribute their children's engineering education both in and out of school setting. In addition, according to parents, EDCPI was also an effective way of PI. In fact, all parents expressed their satisfaction with participating in such a PI activity and experiencing EEE with their children. Parents stated that EDCPI contributed in many ways to them and their child as a PI activity. To illustrate,

> *I think this is a very high-quality PI activity. First, we add something to the child in the sense of engineering knowledge. Secondly, we add a different perspective to the child. It's not just education, it's something different than this. I think this is to give a point of view to the child. Thirdly, we learn our child, we learn the limits of our child, her/his capacity, the attitude during the training. I mean, we know our child. We spent quality time together (P11, post-interview, try-out).*

> *This was a different PI activity. In normal PI activities in preschool classrooms, parents' branches are usually effective, but here this is different. In there, you make parents involve in the process, you enable parents to think and ask questions (P13, post-interview, try-out).*

> *In this five-week period, I saw that we can have fun also with the recycling around, without toys. I understood that I had to call my child's attention more to the things around her and to encourage her to examine. There's more to learn (P12, post-interview, try-out).*

> *Although my child and I knew each other, we got to know better after this workshop. I can see what my son's shortcomings, what he can think of, or how much he can imagine. I've seen how*

much I can teach my son, how and what to tell while teaching something (P10, post-interview, try-out).

The next learning objective was related to parents' changes in the home environment to support children's engineering education. Findings from the pre-interviews revealed that majority of the parents thought that their home environment was appropriate for engineering education. Parents also stated that they could provide the necessary space and materials for engineering education if the children wanted. When post-interview data was examined, it was revealed that most of the parents have not yet made any changes to support engineering education in their home environment. On the other hand, there were some parents who provided their children with open-ended materials and construction materials.

In our neighborhood there is a packing store, my wife had taken the wooden sticks and pipette from there. I bought plastic cups from the market. This weekend I'm planning to go to the stationery to buy the wooden tongue depressors (P1, post-interview, micro-evaluation).

He wanted us to buy wooden blocks. Some of his friends have these blocks, but we did not have. My son saw them in the children of our friends but never asked us to but it before. I bought it today. He is impatiently waiting for me to go home right now. Maybe he will do a lot of things by using these blocks (P4, post-interview, micro-evaluation).

One parent stressed that they started to collect recyclable materials with her/his child to make new designs at home while three parents planned to collect such type of materials. Besides, one of the parents stated that, after participating this study, she provided a worktable for the child to perform activities with open-ended materials whenever he wants. As seen in the following statements, the findings regarding with this learning objective revealed that parents gained a new perspective towards open-ended materials after this study. Indeed, most of the parents stated that they did not look to open-end materials as waste, and that these materials could be used for educational purposes. For instance,

Before this workshop, when my son wanted to do something with these materials, I was taking away those materials from his hands by saying that they were garbage and that we should throw them away. Now, when my son wants to do something, I let him use these materials, and also scissors and tape. Normally, he always used it when he had homework, and then we were removing these materials when the homework was over. Now paints and other materials are always standing on the table and he can do something whenever he wants. I mean, the materials are at his disposal (P2, post-interview, micro-evaluation).

We're collecting open-ended materials. More precisely, my son is collecting as much as he can, because his curiosity awoke. Beforehand, I was intervening and saying that "What is it, what will you do with it?" But now, I am saying that "Let's collect and put them in a bag, my son. We can do an activity by using them (P9, post-interview, try-out).

During this workshop, I saw that something could be done with things that would not come to our minds. I mean, we created designs with the materials that we regarded as trash beforehand (P3, post-interview, micro-evaluation).

Parents' feeling comfortable while working with their children in engineering was another learning objective of the EDCPI expected to be reached by parents. In this regard, the self-efficacy of the parents was based on the evaluation of this learning objective. When their initial parental self-efficacy in supporting their child's success in engineering was examined, findings indicated that all the parents except for one felt themselves efficacious in supporting their children's engineering education. Parents said they could support their children in the subjects they knew, and they could research and learn the subjects they didn't know. On the other hand, one of the parents stated that she was illiterate and therefore she could only support the child together with her husband. She expressed herself in the following way.

We can help my child's engineering with my husband. I cannot help him because I am illiterate, but my husband helps us (P7, pre-interview, micro-evaluation).

According to the findings, as in before participating in the study, most of the parents had high self-efficacy in contributing their child's EEE. In the following excerpts, two examples are presented.

For example, I can ask different questions to my child no longer. "How does this happen; How does this move?" Besides, in this process, I was very happy to see my child do different things. And as I said, I can ask my child any questions about everything no longer. "How it works; which material it had made of, what would happen if it had been made of something else? That is, I think it was a nice PI activity (P13, post-interview, try-out)."

Of course. I have seen in this process that I can support my child. Even if the activity is very simple, it is important to find out what is inside the child (P10, post-interview, try-out).

On the other hand, one of the parents reported that she did not felt herself efficacious in working her child and contributing her engineering education. According to this parent, she might be insufficient to implementing such a planned engineering activity at home environment. She expressed her thoughts in the following way.

I can supply materials, but it doesn't end with materials. We should follow a process like we do at the workshop. For example, we measure, then we build our model. I mean, we need to route, we cannot do it our own. I mean, I think if I'm more intrusive. I don't think she will do it herself. Even if I don't help her, she wants help. If there is an expert teacher, she can't ask for much help and tries to do it on her own. I think I don't care with her so much and I can't be sufficient for her (P12, post-interview, try-out).

Similarly, one parent reported that he could not support his child as much as he desired, but his reason was different from the abovementioned parent. This parent reported that he could not require time to involving his children's education due to his workload. These findings signified that low self-efficacy and the life context of some parents might be a barrier for parents to continue their involvement in their children's engineering education in the home environment. On the other hand, as seen in the following excerpts, some parents stated that such a PI activity in the school environment gives them the opportunity to move away from their work and life intensity and spend time with their children. These findings are parallel to the findings related to parents' desire to participate again such a PI activity which will be conducted in the school environment. In fact, all the parents reported that they wanted to participate such an PI activity if such a workshop would be organized again. Some even stated that after the workshop was over, the workshop would last more than five weeks and that if the study was to be held again, the researcher would ask them to inform them.

> *I can't lie, we don't have a chance to do something with the child at home. In this workshop, there was a very nice way to communicate, so it was a beautiful environment. I was very pleased to be participating. We will be glad if there is more, I hope we will have a chance to participate again (P2, post-interview, micro-evaluation).*

> *I would like to participate in the school environment if it is done again because I think that I cannot find the opportunity in daily life. In the comfort of the house, perhaps I cannot do it in a program and do it in my own frame. However, when it is given as homework in the school or when such an activity is organized again, I voluntarily attend. I can't devote this time to my child at home. When someone redirects me, I can devote this time more comfortable (P11, post-interview, try-out).*

> *I had a new baby. I also have a shortage of time because I work. I saw my son happy in this workshop. We returned home in a way that we did something together. This is a relief for me. Because when I'm home, I can't take too much time for my son. I can only spend time doing his homework or meeting his needs. This workshop comforted me conscientiously. We've done something with my son (P10, post-interview, try-out).*

On the other hand, some parents reported that if such a PI activity based on engineering education is provided with them by the teacher, they could not participate each weekend as in this study. According to them, this kind of a parent-participated engineering activity can be organized by their teachers once a month or bi-weekly.

> *I would participate in such an activity again, but I would not participate in every week (P12, post-interview, try-out).*

> *I'm newly appointed, and this year I'm not allowed. But I'd like to join when I'm allowed. I would like to do this with my child all day or half a day once in a week. But if we spread this over time, it wouldn't be every weekend. It could be once a month or once in three weeks (P11, post-interview, try-out).*

Even if most of the parents had high self-efficacy in contributing their children's engineering education, some parents reported that they had some difficulties while working with their children on engineering activities. Their difficulty was mostly due to the distraction of their children during the activity. To illustrate, *For example, when the roof was set up, then lined up bars, not laid. I had to say, "Come on, girl, let's stick it, girl, let's get these together." I don't want to force the child, but I don't know how to encourage it (P11, post-interview, try-out).*

I criticize myself, in the first week my son failed the model of the roof and he constantly blamed me. That's why I always took his work, I realized it later. ...He constructed a model by using toilet paper rolls. I told him we saw the toilet paper get wet, but he did it anyway. He put the rollers upright and added foam plates and stones on top of them. Then he saw it was getting wet. Throughout the activity to me constantly "I told you to it will get wet," he said. When he couldn't do it, he was upset, and he hit my leg. When he felt insufficient, he thought, "You did it." I, too, have interfered too much with the thought of maternal instinct (P13, post-interview, try-out).

Findings also indicated that not only EDCPI, but also the parental training carried out before the implementation of the EDCPI activities provided parents a wide variety of contributions. According to the parents who participated in the try-out study, this training provided them with knowledge about EEE, scaffolding strategy and how they could support their children's engineering and science learning. To illustrate,

Obviously, I'm imposing my own ideas, but I realized that I should leave the child a little more comfortable, and not have to put pressure on her. I mean, the training showed us to work through channels (P12, post-interview, try-out).

For example, we learned that we should not interfere with the child, that we should be guided but not directed. When we intervene so much in children, he cannot be too productive because he cannot reveal his own character. I thought I was taking too much of my own child. I've seen my shortcomings about it. I'm trying to change (P9, post-interview, try-out).

Parental training had a great impact. During the activities, I tried to approach my son thinking about what was told in this training (P10, post-interview, try-out).

I can say that there is a contribution to a person with no knowledge about engineering, like me. I mean, I remember the part of problem determination, idea generation, developing, sharing. This training informed me about engineering and guided me through the process how I should guide my child (P11, post-interview, try-out).

One of the parents stressed that she knew the scaffolding and utilized from it in her child's education process. On the other hand, she reported that she understood from this training that parents should not interfere with their children in any way. She also reflected that this parental training was effective on her knowledge about how she can guide her child in design process. This parent's statement is presented in the following excerpts.

Especially when we try to teach my daughter something, we usually use this strategy. You know, Socrates has a teaching method. He teaches slaves geometry, asking questions and taking answers. He argues that knowledge is hidden within man, by asking the right questions, that knowledge is extracted, and applied learning is more permanent. In this direction, in fact, my purpose is to apply it to my child. So, ask the right questions and let the child find the truth. By considering that, in the activities, I directed my questions to the child in this four-step EDP process. I asked my child such type of questions; what is the problem here; what are we trying to do; how can we do it; let's draw it, how to draw it? (P11, post-interview, try-out).

Findings also suggested that some parents need more support to provide effective scaffolding to their children's engineering-related learnings. In fact, one of the parents stressed that the training might be developed by adding more examples and explaining more clearly to the parents what they should do in the EDP to guide their children. The parent explained her thoughts about the parental training in the following way.

> *In the training, it was told that we would be with the child in the education process but would not interfere. I didn't understand what it meant for the first week. Then, I realized what you want to tell after experiencing the process. In fact, parental training can be kept a little longer, and parents can be explained in a slightly more descriptive way. Besides, this training can be given one day or one week before the workshop and in the form of a two-course presentation to parents. More examples could be added to the flow of the presentation (P13, post-interview, try-out).*

The last learning objective was related to parents' awareness of their children's progress in engineering. Findings of the both post-interviews and parent journals revealed that parents were aware of their children's development and monitored their children's progress in engineering. In other words, in the beginning of the study, while parents' awareness about engineering-related behaviors in their children's activities were limited, findings revealed that, during and after the study, parents became more focused on children's engineering related behaviors. In addition, the findings of this learning objective revealed that children's interest in engineering continued at the home. In fact, a large body of the parents reported that their children wanted to construct new designs at home. After the third activity, children could bring their designs to the home. Some parents reported that their children continued to make trials with their designs. Parents reported their observations on their children's interest after this workshop in the following manner.

> *I liked that my daughter wanted to do something with me again at home. She's measuring everything. She comprehended the method, first she created a model and then wanted to solve the problem. Besides, when she failed, she didn't give up immediately. Beforehand, she was squeezing it immediately. I have observed that my daughter is better than before (P12, post-interview, try-out).*

> *One day, when we back home in the evening after the workshop, he said me "Mom, our design was very nice, but next time we would use plastic instead of carton, would it be better?" He began to collected toilet paper rolls, plastic items, pet bottles or something. "Mom, we can do that with this one" he says to me. After the last activity, he wanted to design a chain reaction system with the wooded blocks, he hadn't played with them for a long time. He reached a solution by trying it again and again (P9, post-interview, try-out).*

> *I think it's probably related to this workshop we participated. She was very keen on designing a house for our cat. They had made one, now she wants to do one more. Besides, the cat scratches our daughter, they cannot get used to each other. She tied a toy to the end of the rope to use it when they were playing. She made herself a toy he could play with the cat. It didn't require a great engineering skill, but the child had a problem and she did something to solve the problem. Beforehand, she had preferred complaining about the cat was scratching her. Now, she has found a solution (P11, post-interview, try-out).*

My son is doing more on his own, more confident no longer. When choosing the materials to use, he is selecting more suitable materials for the problem. He is realizing the shortcomings of his design without the need for warming (P13, parent journals after the fourth activity).

He thinks better than me, he plans. I mean, today he told me he wanted to do something with toothpicks. He's drawing plan. I asked him what to do, he said he would make a product using toothpicks (P7, post-interview, micro-evaluation).

He's obsessed with the idea of an aquarium right now. He's trying to build an aquarium. For instance, he cuts water bottles and places them. He tells me his plan. He says where the air will get into for the fish. I would throw the bottles in the garbage because I supposed they were garbage. He said I couldn't throw the bottles because it was his aquarium. Then, he started to explain his design. He started to produce such type of ideas after the workshop, and he hadn't thought of it before (P2, post-interview, micro-evaluation).

There was an electric circuit system at our home, we didn't get it installed before. The other day my daughter brought the circuit system again, she asked me to establish it again. We tried to re-establish that circuit. In addition, we designed a pulley system to brought three marbles to the bird's house and brought our design to our home. It's still at home. My daughter experimented with it for a long time. Especially, the first day was so amazing. She spent all day experimenting with that system. She made a video call with her uncle, and aunt and showed how she did the design and how the design worked (P8, post-interview, micro-evaluation).

In summary, the findings revealed that the activity implementation process and the parent training contributed to the parents' understanding of engineering and technology and their knowledge of early childhood engineering education. The findings also indicated that EDCPI contributed to the knowledge of parents about the scaffolding strategy and expanded their definition of PI. In fact, after the intervention, most of the parents' definition of PI also included collaboration with children and support engineering education. On the other hand, the findings showed that parents were open to PI activities to support engineering education, especially in the school environment and needed further support in this regard. All these findings shed light on the possible contributions of the designed and developed curriculum to parents. In the next section, the findings regarding the contributions of this curriculum for teachers are given.

4.1.4.3 Possible Contributions of EDCPI to the Teachers

As a requirement of the design process, teachers played an active role in the whole process from the design of the curriculum to its development and evaluation. Therefore, the contribution of the intervention not only to children and parents but also to teachers was also investigated. In this context, this section focuses on interpreting EDCPI's contributions to teachers through their self- reports.

Findings obtained from pre-interviews indicated that preschool teachers had limited knowledge about engineering in early childhood. In fact, they described early years' engineering as children's activities based on bringing together pieces of open-ended educational materials such as Lego, building blocks, and plug-in toys and creating a product. Two excepts exemplifying this case are presented below.

> *Playing with the building construction toys, doing different things by doing the Legos on top of one another, or creating a new thing by plug-in toys. For example, one of them brings the product s/he created and says that "Teacher, look, I made a giraffe" or says "Teacher, I made a missile launcher ramp." (T1, pre-interview, micro-evaluation).*

> *It seems to be engineering stereotypes for boys. For example, they build bridges, cars, buildings with blocks. But the products created by girls some educational materials like plug-in toys seems me to be engineering. For example, the other day, one of them had created a headset for her baby which is appropriate with the baby's sizes (T3, pre-interview, try-out).*

According to the post-interview findings, with the help of EDCPI preschool teachers to look early engineering through a wider perspective. In fact, findings reflected that after the intervention teachers' definition of engineering in both early years and daily life included problem-solving and trial and errors. To illustrate,

> *Engineering, revealing a product and thus solving a problem there is actually in every aspect of our lives. It's the same in kids' lives. I'm observing it also in the classroom. The children who participated in this training started to play with the building materials for a bit more goal oriented. I began to observe this directly. I mean there is engineering in every field. I also thought that I could think of myself as an engineer, rather than to see engineering as a profession and that I could do something to make my life easier, even though I had not studied engineering. Similarly, the child can design some things to make his / her life easier by a number of trial and errors. I did not see that they gave up after the second third attempt (T1, post-interview, micro-evaluation).*

In addition, preschool teachers who participated in micro-evaluation and in try-out study reported that the EDCPI increased their motivation in the matter of their profession and of integrating STEM into their classrooms and contributed their professional development. In fact, teachers reflected that EDCPI developed their self-confidence, changed their perspective in the matter of ECE practices and that EDCPI made them think about how they can teach scientific concepts to preschoolers. Teachers expressed themselves in the following way.

> *No longer, I think that it is necessary to do activities by addressing different perspectives of the child and including mathematics and science. I realized that I did not enjoy the stereotyped and closed-ended activities, and I realized that this process motivated and excited me more. It also contributed to my professional development. Indeed, I thought I should free the children more (T3, post-interview, try-out).*

> *My point of view has changed. I started thinking what I could do. How can I adapt engineering to my class now? In that sense, it added positive things to me. Besides, through these activities, I started to think about how to explain the scientific concepts and contents that I was not interested in before. I learned the branches of engineering that I did not know and the areas in which engineers working in these branches worked. Sometimes there were concepts I didn't know or heard, so I searched the Internet. In that sense, they contributed to me (T2, post-interview, try-out).*

It was really motivated to do more activities with a small number of students and parents. This process added another experience to my 15 years of professional experience. I already told you that I want to do something about STEM. Thanks to this study, I started with engineering which is a branch of STEM. I started to think about what I can do differently, how I could apply it in my class, and how I could adapt these objectives and indicators to my class. I am more curious about what I can do in terms of implementation. In that respect, I began to see myself differently. My self-confidence has increased (T1, post-interview, micro-evaluation).

Teachers also pointed out that they had heard the STEM before or saw some sample activities on the internet. On the other hand, they reported that there were some unclear points in the sample activities they encountered on the internet or books and these resources were not enough for them. This uncertainty was concerned with explaining some of the concepts involved in the activity or the cause and results of the observed events to the children by using child language. Teachers therefore stated that they could not fully understand STEM and did not apply it in their classes before participating this study. To illustrate,

STEM is not very common in Turkey; it is also an area of incorrect implementations. Especially in preschool level, I did not hear much of such practices. There are only a few activities on the internet, and they are just experimenting. Those activities are also translated from foreign websites, usually from abroad. They may not be appropriate for our culture or our children's readiness and developmental level. They like the experiment, but the child only sees the process, does not know why. Why this money is sinking or not sinking? There are activities that we cannot explain why. You know, I really motivated from a professional point of view and I will make a STEM center in my classroom during the seminar period (T1, post-interview, micro-evaluation).

We follow some websites. In the resources available on the internet, science experiments are generally offered as STEM activities in pre-school education. However, there is no science, technology, engineering and mathematics in STEM? For instance, they designed a robot by bluing open-ended materials on the cardboard and decorated it. I think the robot can be designed again, but each child can design her/his own robot according to her/ his own imagination and the robot function that s/he designed have a function. Therefore, I have some question marks on my mind about STEM (T3, pre-interview, try-out).

As in the following excerpts, teachers stated that EDCPI provided them with a perspective on STEM. In fact, after the intervention, T1 and T3 reflected that they could lay a foundation of some scientific concepts by providing children with hands-on learning experiences, could create awareness in children, and enable to establish connections between the learnings with real-life experiences. On the other hand, T2 pointed out that she noticed through this study that implementing STEM required serious planning.

I cannot tell some concepts to my students as if I tell it to the high school students, but with a small design, the child can see these concepts in terms of concrete. For example, instead of using ready-made scales, I saw that I could give the balance to the child through a design we made. I saw that I should be going to start building the basics of this and awaken their awareness. In other words, the child will be able to use the knowledge s/he learned in the classroom in another setting. For example, when s/he played in the playground, she would say, "look, it is standing in balance also here" or "I applied force here too" (T1, post-interview, micro-evaluation).

The process changed my perspective on STEM. For example, I saw that saying that "There is a method called STEM, let's design a roof today by using STEM method" is not enough. This is a process including a truly systematic implementation and requires making serious planning to integrate into the curriculum that you implement. That is, to say that "I used STEM method today", you need to bring it as a whole from the beginning to the end (T2, post-interview, try-out).

Another contribution of the EDCPI to the teachers is related to their understanding of science in ECE. Indeed, teachers reported that EDCPI allows them to understand the importance of hands-on and concrete learning experiences in science education for preschool children. Moreover, teachers pointed out that, instead of demonstration and direct instruction, science education should provide children with a meaningful learning process based on observation, active involvement, and learning with fun. To illustrate,

Clearly, in our classrooms, we make some experiments and try to tell this to the child. However, I was asking myself this question a lot "I'm doing this experiment but what do I teach the child?" In this sense, I was criticizing myself. An experiment I've done just to do will have no meaning and contribution to the child. But this time, I say myself that "I don't need to deal with it, I don't have anything to give to the child." However, in this workshop, we focused on a completely scientific process, with activities in this curriculum. In the process, there was nothing unclear for the children, because they practiced themselves. It was easier to observe for the child because s/he was practicing himself/herself. S/he chose the material herself, applied her/his solution. S/he created a model, designed it, and saw whether her/his solution solved the problem. The child observed it. Therefore, everything became more concrete, nothing remained mysterious. It will not be equal to what the child is told and what the child is involved in. Such a learning will be more permanent (T2, post-interview, try-out).

I've paid attention to these activities, children are much more excited about the scientific activities, it sounds different to them. We always try to keep children in a certain mold. Children are also fed up with continuous cut paste. Children become freer in this type of work and so they enjoy more. Therefore, during these activities, I certainly realized that children both acted more freely, they were happier and more creative. Besides, science is an abstract concept for children, but many concepts in these activities have become concrete. Yes, maybe they are not aware that what they have learned is a part of science, but these are the basis for the future. Perhaps in the future, they will be able to perceive science much more easily (T3, post-interview, try-out).

When it comes to the preschool teachers' beliefs and implementation about PI, findings obtained from the interviews revealed that EDCPI provided preschool teachers with an alternative way for PI. In fact, before the intervention, preschool teachers defined PI as a time period in which the active association of the child and the family could be ensured and shared together. Teachers also reported that they implemented both home and school-based PI activities such as coming to the classroom and introducing her/his job to the children and doing activities with their child in the classroom environment and doing homework with their child. To illustrate the PI activities that teachers reported that they implemented in their classroom,

I called all the parents to school one day and asked them to take one hour off from the workplaces. Together with the children, we identified three or four activities. While performing *these activities, parents acted like children, and children helped them as parents. That's they changed their roles. Children helped their parents and said something like that "Now you're going to hold the scissors; we're going to do it like that." The child guide was mother and father student (T3, pre-interview, try-out).*

I think that PI is all kinds of activity in which parent contributes her/his child and the child becomes happy. Now we are entertaining a parent in our classroom and she is making pickles with the children in the classroom. Every child brought the jar, brought the pickle material. The children are looking at the taste of the ingredients they bring. Every child will establish his own pickle under the guidance of that parent and me. And after they're pickled, they will look at their taste. Once, I had a parent who had pet shop, s/he brought a dog to our class. S/he told the children where the dog lived, the species, the characteristics. They both learned about the animal and the children loved the animal, they were happy. Certainly, I include the parent, that is, once a year, every parent comes to the classroom (T2, pre-interview, try-out).

On the other hand, after the intervention, teachers reported that they motivated to try STEM-based engineering activities which is like the activities in the EDCPI with the participation of all the children and parents. Two of the teachers expressed their views in the following way.

I strongly believe that I should organize PI activities in this way…In such a PI activity, I think it would be very nice that parents remain in the background and work with their children collaboratively. I think parents are too bored with the classical rituals of kindergarten. This kind of thing brings a different perspective to them. Obviously, I didn't intend to do PI this year, but when I went home after the first activity. I thought I should do such a PI. I want to do this with all the kids and parents in my class (T3, post-interview, try-out)

…After these activities, I have started to think that I could plan such a family participation activity and do different things in the classroom. It may not be so professional, but at least I can hold one end (T1, post-interview, micro-evaluation).

T2 said that this PI activities was carried out with a small group of parents and children within the scope of this study but wondered what would happen when she tried out with a more crowded group in her class. Therefore, she reported that she would try STEM-based engineering activities in her classroom with a more crowded parent-child group.

I will try an engineering activity in which a more crowded parent-child group will be included. I'm thinking of what kind of activity I'm going to do. I think what I can observe. There were teachers who gathered all of the parents in the class from time to time and played games, but I didn't do any activities with such a large group of parents. For me it would be a new experience, therefore, I wonder how it happens (T2, post-interview, try-out study).

To sum up, teachers' self-reports and the comparisons made between pre-and post-interviews revealed that EDCPI contributed preschool teachers' knowledge of EEE, their professional development, their motivation to PI and their profession, their perspective of STEM and science education.

CHAPTER 5

CONCLUSIONS AND DISCUSSION

The current study aimed to design and develop a STEM-based (Science, Technology, Engineering, and Mathematics) engineering design curriculum for parental involvement (EDCPI) in early childhood education (ECE) including the learning objectives, activities, and assessment tools in order to support preschool children's learnings in STEM. This study also aimed to explore the factors that should be taken into consideration in the design and development such a curriculum and to reveal the possible contributions of this curriculum to preschool children, parents, teachers. In line with these purposes, this chapter includes the conclusions of the obtained findings and discussion of these findings under the guidance of relevant literature. It also addresses the implications of the study for educational practices, and suggestions and implications for further studies under the consideration of the limitations of the current study. Thus, this chapter consists of four main parts. The first part involves the discussion of the main characteristics of the designed and developed early engineering design curriculum. The second part focuses on the discussion of the possible contributions of this curriculum to children, parents, and teachers. The next part presents the implications of the study in terms of educational practices. Finally, the fourth part presents the limitations of the current study and its implications and suggestions for following studies.

5.1 Characteristics of the EDCPI for Preschoolers

The design-based research (DBR) process followed in this study and the obtained findings throughout the process enabled the researcher to determine the main characteristics of an intervention designed for supporting preschool children's learning in engineering and STEM. During this process, following the steps of a structured process through this design-based research has facilitated the researcher's work. In fact, the literature review and context analysis conducted in the preliminary research phase enabled the researcher to focus on the factors that should be considered while designing a curriculum for preschool children in a general context and specifically in the engineering context. In this way, eight draft of design principles were identified. First, developmental appropriateness was identified as the main characteristic of a curriculum aiming to reach preschool children. In this regard, it was identified that, in the EDCPI, learning objectives should be clearly identified and articulated

(Copple & Bredekamp, 2009). Besides, such a curriculum should be consistent with the classroom and the real-life experiences of preschool children (Dubosarsky et al., 2018), and should be appropriate with their developmental needs and characteristics (Cunnigham & Lachapelle, 2016; Davis et al., 2017). Other requirements for the developmental appropriateness were possessing the features of flexibility and adaptability and consistency with the current early childhood education (ECE) curriculum (Copple & Bredekamp, 2009). In addition to being developmentally appropriate, EDCPI should be a balanced curriculum in terms of its learning objectives (MoNE, 2013), should be based on learning by discovery and learning by designing (Bers, 2008), and should provide children with learning experiences in STEM (Stone-MacDonald et al., 2015). These learning experiences should also be based on creativity (Cunningham & Lachapelle, 2016), on the usage of daily-life materials (Cunningham, 2009) and on PI (Dorie et al., 2014; McClure et al., 2017). Finally, in EDCPI, both children and the learning process should be assessed in a versatile way. These eight characteristics were described in detail in the literature review and the findings chapter of the study. These characteristics derived from the relevant literature and revised over the course of the prototyping phase, which assisted the researcher in constructing the content of EDCPI. Furthermore, these design principles have the aim of guiding further research by providing substantive and procedural information for the design and development of an intervention to support preschool children's learning in engineering and STEM (Plomp, 2013).

In the iterative cycles of the design process, the prototypes of the EDCPI was formatively evaluated and modified based on the literature review and expert appraisal in order to provide its relevancy with the intended curriculum (content validity) and consistency among the curricular components and with the current knowledge in the related literature (construct validity). Both the practicality of the EDCPI for target users and its effectiveness in terms of reaching the intended learning outcomes were verified with preschool children and their parents by means of two different iterations. In fact, these were four main quality criteria for a curriculum (Nieveen, 2009; Thijs & van den Akker, 2009) and were fulfilled through the formative evaluation process in the current study.

As for the final design principles of the study, the implementation of the curriculum with the target users revealed that some modifications of the draft design principles needed to be made. One of these was the need to replace the phrase "parental involvement" with the term "parental scaffolding", and, thus, make changes to the content of the parental training. In fact, the starting point of this study was that parents were an integral part of education and that they could make an undeniable contribution to their children's STEM and engineering education (Dorie & Cardella, 2014; Gunning et al., 2016; Smetana, et al., 2012; Šimunović, Ercegovac,

& Burušić, 2018). On the other hand, the micro-evaluation findings indicated that the parents' excessive intervention in the learning process impeded children's learning and interrupted their focus on the activity. In a similar study, Beals and Bers (2006) observed similar findings in a robotic workshop, to which some children participated with their parents and some did so without their parents. According to the findings, the projects created by the parent-child groups were more complex in terms of building and programming when compared to the ones created only by the child. However, the findings obtained at the end of the study revealed that children who participated in the workshop without their parents learned more than those who participated with their parents due to the excessive involvement of the parents.

From a theoretical point of view, working under the guidance of a more talented person can provide a skill that cannot be achieved independently (Vygotsky, 1978). On the other hand, when this guidance was not provided in an appropriate way, the involvement of the parents in the education process may sometimes prevent the children from learning effectively (Beals & Bers, 2006). According to the findings of the current study, parents' excessive interference was found as the main barrier to the EDCPI. Parents' excessive interference was associated with the difficulty of the activities, their hastiness, the distraction of children during the activity process, and children's tendency to easily give up in case of failure. Findings also revealed that parents' excessive interference stemmed from their lack of knowledge about how to guide their children's education. In fact, prior to the implementation, the parents were informed and trained about what they could do to support their children's engineering and science education. However, the micro-evaluation study showed that parents need to know how to do this without being over-intrusive, and they need more specific definition of their role in the process. Therefore, the relevant design principle and the content of the parental training was modified and re-implemented with this modified form.

Subsequently, findings revealed that most of the parents were less intrusive, and children were more active and eager towards the activities in the try-out study. In fact, the produced design solutions reflected the child's engineering design process (EDP) rather than those of the parents. In this way, child-related learning objectives were more observable for the teacher and the researcher throughout the design process. This could be related to the differences between the characteristics of the children and parents who participated in the micro-evaluation and try-out studies. Besides, this could also have stemmed from the modification made in the parental training. In fact, the findings revealed that this modified version of the parental training provided parents with the knowledge of early engineering education (EEE) and how to scaffold their children's learning. On the other hand, an excessive interventionist attitude of especially some parents was observed from time to time in the try-out study. This situation could be associated with parenting styles (Baranovich, Fong, & Hutagalung, 2019). As Baumrind (1966) stressed, authoritarian parents tend to control their children's behaviors more and show less respect to the child's unique behavioral tendencies. Similarly, in the current study, parents could have had different parenting styles (e.g. authoritative, authoritarian, and permissive) and this might have been effective on the way they become involved in the process. On the other hand, such a PI practice presents parents the challenge to find and protect the balance between providing the child with support through developmentally appropriate scaffolding and interfering with the child's learning (Beal & Bers, 2006). This study showed that when parents succeed in this challenge, they can support their children's learning in both engineering and in the other disciplines of STEM.

In addition to the learning process based on parental scaffolding, another main characteristic of the EDCPI was specified as developmental appropriateness. The first requirement of a developmentally appropriate curriculum is the clarity of the learning objectives (Copple & Bredekamp, 2009). As in the curricular spider's web proposed by van den Akker (2013), findings revealed that aims and objectives are among important curricular components of the EDCPI. In fact, during the design process, the entire curricular content is structured around the EDCPI learning objectives. On the other hand, it is not enough to structure learning aims and objectives. In parallel with those reported by Copple and Bredekamp (2009), the findings revealed that the learning objectives needed to be clearly identified and articulated to the preschool teachers, who were among the target users of the curriculum. According to the findings, such a curriculum would provide teachers with more guidance, especially during the assessment of the learning process and children. The findings revealed that preschool teachers experienced some difficulties in understanding some of the learning objectives and the relevant indicators due to some points that did not seem clear to the preschool teachers. On the other hand, in the final prototype of the EDCPI, the learning objectives were structured by considering teachers' feedback according to the clarity of the learning objectives.

Another characteristic of the EDCPI with respect to developmental appropriateness was consistency with the classroom and real-world experiences. According to the findings of the present study, when there is a close match between children's learning experiences in engineering and their experiences in and out of school, children can activate their previous knowledge and transfer their learning in other fields to the design process and engineering learning to daily life. In line with the view of Cunningham and Higgins (2015), this finding suggested that engineering projects should be presented to children in a real-world context to demonstrate the areas where engineering knowledge and tasks were used. This study revealed once again that engineering was an integral part of children's daily activities and therefore children were familiar with engineering. In parallel with that reported by Cunningham and Lachapelle (2016), this study also indicated that when they were provided with engineering experiences in the real-world context, children could understand the importance of engineering for living beings, environment, and society. In addition, a developmentally appropriate curriculum needs to be appropriate to children's interests and developmental needs and characteristics (Copple & Bredekamp, 2009). In this direction, Cunningham et al. (2018) defend that developmental appropriateness of the context of the engineering problem for children aged 5-6 can be provided by introducing the content through puppets, stories, the characters in these stories, and using supplementary pictures and examples. Similarly, findings of the current study showed that the use of hand puppets to present engineering challenges, the use of various visuals to explain some concepts, and the presentation of problems within the context of stories enabled the EDCPI to address children's interests and needs. Cunningham et al. (2018) also point out that children in this age group have the potential to design technologies having a single function by considering up to three constraints. In parallel with this view, it was observed in the current study that preschool children could produce technologies to solve problems by considering three different constraints. Besides, in the third activity, the children in the study were expected to produce a design with two different functions (collecting both small wastes and big wastes), and some of the children managed to do it. However, it should be considered that these children were older than 72 months.

Other characteristics identified for EDCPI were its flexibility and adaptability, and its consistency with the current ECE curriculum (Copple & Bredekamp, 2009). Findings obtained from the implementations revealed that EDCPI possessed these characteristics and that, from this aspect, it provided preschool teachers with motivation to implement STEM-based engineering activities in their classrooms as a PI activity. According to the teachers, the flexibility of the EDCPI would allow them to integrate activities such as play and movement into engineering when they would implement it in their classrooms. Moreover, the findings revealed that teachers needed to know the learning objectives provided by such a research-based curriculum in order to be able to integrate engineering into their curriculum. This finding supports the idea that a curriculum should include some standards but should leave room for the teacher to adapt in accordance with the needs and skills of the students (Cunningham et al., 2016; NAEYC, 2009; Null, 2011). The findings also showed that EDCPI is in parallel with the current preschool education curriculum. Indeed, according to the findings, EDCPI can play an important role in supporting children's learning of many concepts and skills included in the curriculum.

As aforementioned, being balanced in terms of learning objectives, providing learning experiences based on learning by designing and discovery, providing preschool children with learning opportunities in other STEM disciplines also, entailing learning activities grounded on children's creativity and the usage of daily-life materials, and utilizing versatile assessment are other characteristics that EDCPI needs to possess. The findings of the present study are in consistency with these characteristics. In addition, they coincide with some research findings in the relevant literature. Firstly, findings of the current study indicated that learning by designing and learning by discovery were characteristics that emerged spontaneously in an engineering design curriculum providing children with an effective EDP. For example, findings of the current study revealed that children experienced the steps of engineering design and they learned a wide variety of knowledge and skills throughout the design process. Moreover, the constraints of the activities and the emerging problems they encountered during the EDP provided children with new discoveries (e.g. children sought ways to immerse plastic containers in water to collect the wastes at the bottom of the river; they discovered some physical science concepts such as *incline* and *force* while testing their models). Similarly, it is supported by other researchers that the learning process based on learning through design (Bagiati & Evangelou, 2018; Martinez & Stager, 2013; Purzer & Douglas, 2018; Stone-MacDonalds et al., 2015) and discovery (Cunningham & Lachapelle, 2016; Moomaw, 2013) accompanies engineering education in early childhood.

Secondly, findings revealed that engineering activities should provide children with knowledge and skills in STEM disciplines by presenting these disciplines in an integrated way with each other and with the real world. As Cunningham et al (2018) highlighted, an engineering curriculum should encourage children to apply their science and mathematics-related knowledge and skills to the problem-solving process. The findings of the current study revealed that children could be exposed to various concepts related to science and adopt some mathematical skills within a single engineering activity and produce simple technologies to solve the problems presented to them. This finding supports the previous studies which revealed that engineering design activities can provide young children with new learning experiences in other STEM disciplines and reinforce their existing knowledge and skills in these fields (Bagiati & Evangelou, 2016; Bairaktarova et al., 2011; Donegan-Ritter, 2017; Draper & Wood; Meeteren & Zan, 2010; Park, Park, & Bates, 2018; Raven et al., 2018; Tank, Rynearson, & Moore, 2018; Tippett & Milford, 2017). Thirdly, as Cunningham and Lachapelle (2016) emphasize, design challenges should entail low-cost, ordinary, and easily obtainable materials. Thus, engineering could be perceived by teachers and students to be more achievable, implementation of engineering could be possible in schools with limited funds for materials, and children can to continue their engineering-related experiences outside of school also. Similarly, in the current study, it was revealed that the satisfaction stemmed from working with open-ended materials was the most observed feelings of children, and these open-ended materials enabled children to reflect on their creativity in designing their products. Fourthly, in an engineering curriculum addressing preschool children, assessment should be versatile and should focus on both the learning process and products. As Purzer and Douglas (2018) emphasized, in engineering design activities, learning is exhibited via a wide range of means and diverse forms of evidence. Hence, in an engineering design curriculum, assessment should be based on measurements that can generate qualitative and quantitative data (Cunningham & Lachapelle, 2016), and the documentation technique should be used (Mcafee & Leong, 2012). Findings of the current study revealed that each child's ways of thinking and the interaction between each parent-child group were different from each other. Therefore, versatile assessment based on observation and evaluation of the entire design process was essential in such an engineering design curriculum. In addition, the findings showed that in EDCPI, assessment should be aimed at understanding the child's way of thinking and the rationale behind the steps taken at each stage of the design, for which the teacher should scaffold the child with various questions and develop an understanding of the style of thinking. In other words, findings indicated that, in addition to the assessment tools, documentation, and the sample questions involved in the activity templates, various questions asked spontaneously by the teacher during the design process was important for assessment.

In conclusion, eight main characteristics were identified and validated under the guidance of relevant literature and improved by means of the findings obtained from micro-evaluation and try-out studies. During this process, following the design-based research methodology enabled the researcher to identify these main characteristics by focusing on different dimensions of this curriculum, such as PI, engineering education, and curriculum development and to develop them in accordance with the findings obtained from the participants. In this regard, the findings pointed out the need for some modifications on two of the design principles. Indeed, in the draft form of the design principles, a learning process based on the involvement of parents was identified as one of the caharctersitics of the EDCPI. However, especially the second iteration of this design-based study indicated that in such a learning process involving parents might include parents' excessive interference with their children's learning process. It was found that this excessive interference sometimes disrupted the child's learning process by distracting the child's attention during an activity, and because of all these reasons, parents' excessive interference was a barrier to such a curriculum including parents in the education process. Therefore, the term "parental involvement", which was one of the draft design principles, was changed as “parental scaffolding” in order to emphasize that what was expected from the parent was to scaffold the child's learning process. Thus, parental training was improved in this respect. Another modification was made on the design principle, which characterized EDCPI with versatile assessment. In fact, both the second and third iterations showed that the sample questions included in the activity templates to be asked by the teachers supported the evaluation, but in some cases it was necessary to ask children more specific questions to understand their reasons. In such cases, it was thought that the questions that the teacher would ask spontaneously would facilitate understanding the child's point of view and thus support assessment. From this point of view, the content of the design principle was expanded and attention was drawn to the importance of the teacher’s role in the assessment process. Subsequent to this discussion on the characteristics of the EDCPI, the following section dwells on the discussion of the findings regarding the contributions of the intervention to the preschool children.

5.2 Contributions of the EDCPI to the Preschool Children

The expected contributions of the final prototype of the EDCPI on preschool children’s learning in engineering and STEM were asserted by means of its usage by a small sample of target users. In fact, after the final modifications made to it, the final prototype of the curriculum was not tested through a field study with the target user group and in the target learning environment. Therefore, it is possible to discuss only the expected contributions of the curriculum (van den Akker, 2010). By considering the data provided by a variety of data sources and obtained from different participants of the process, the findings reflected that EDCPI made a wide range of contributions to the preschool children. Throughout the study, these contributions were examined within the scope of the learning objectives and indicators of the curriculum and under four main dimensions. Thus, the findings of the present study in terms of the curriculum’s contribution to children are discussed under these four dimensions as follows.

5.2.1 Engineering-related Knowledge

As explained in detail in the previous chapters, EDCPI was structured around some learning objectives under the dimensions of knowledge, skills, dispositions, and feelings (Katz, 1999). Thus, in the light of relevant literature, EDCPI was designed to include engineering knowledge-related learning objectives and fourteen relevant indicators to be reached by preschool children. These learning objectives were as such comprehending the meaning of engineering and technology, recognizing the products of engineering in daily life, exploring different branches of engineering, developing an understanding that every person can be an engineer, and developing awareness of the importance of engineering and technology for the world.

As Sullivan and Bers (2015) point out, it is important to ensure that children develop their knowledge of the man-made world and their understanding of engineering and technology in order to make sense of the world where they live. The findings of the current study revealed that before participating in the intervention, preschool children had a limited amount of knowledge regarding engineering. Indeed, when children were asked to list the professions they knew, it was revealed that engineering was not among those professions, and most of the children described the engineers on the profession cards shown to them as either a mechanic, robot maker, or a constructor. This finding is in line with the findings of other studies in the literature which reveal that children define engineers as constructors, mechanics or train drivers (Ata-Aktürk & Demircan, 2018; Knight & Cunningham, 2004; Pantoya et al., 2015). The findings showed that only children who had an engineer in their families had an understanding of what engineers do, but this understanding was strictly limited to the specific field of the engineer in the family. However, the EDCPI implemented in the current study was found to contribute to children's understanding of engineering even if they had little or no prior knowledge of engineering. In fact, after the intervention, most of the children were aware that engineers worked to make life easier and help others, and they gave examples of engineering products from their daily life. This finding supports research suggesting that preschool children can gain an understanding of the ultimate purpose of engineers and engineering through a developmentally appropriate engineering education (Bagiati & Evangelou, 2018; Davis et al., 2017; Raven et al., 2018). The study also revealed similar findings concerning technology. In fact, prior to the intervention, most of the children reported that they had never heard of the technology before. In addition, even if they stated that technology was beneficial for people, they could not justify their statements. On the other hand, subsequent to the intervention, most of the children recognized the technologies shown to them and gave various examples to the technologies from their daily life, even if they still could not describe what technology was. This finding also supports the idea put forward by Moore et al. (2018) that engineering provides preschool children with the ground to recognize technology, not only through digital media but in all aspects of the man-made world. In parallel with this finding, the study conducted by Bagiati and Evangelou (2018) revealed that preschool children could exhibit knowledge regarding the existence or utilization of technology.

As emphasized by Cunningham (2009), it is important for children to know the meanings of technology and engineering and have an idea of why they are important for our world and society. In fact, preschool children interact with engineering products in their daily lives and, thus, they constitute a part of today's engineered world (Moore et al., 2018). Nevertheless, the findings of the current study showed that after the intervention, the children could still not explain how engineering and technology contributed to our world and society. On the other hand, all the children made comparisons between the conditions of today and old times by pointing out the facilitator role of engineering and technology in our life. Even if they could not directly express the role of engineering and technology in the development of society and the world, these comparisons revealed that children gained an understanding of the importance of engineering and technology. As Bagiati and Evangelou (2018) emphasize, the aim of early engineering is to provide children with an understanding of the fundamental nature of human activities through its internationally recognized role of management in today's human-made world. In parallel with this view, it can be said that EDCPI fulfills this aim of EEE based on the findings obtained from the study.

The findings showed that the majority of the children, including those whose parents were engineers, did not have knowledge of the various areas of engineering, and that this situation had an impact on only some children after the intervention. In other words, it was found that the objective of the curriculum related to making children aware of the various branches of engineering and the technologies produced by the engineers working in these branches was only achieved by some of the children. In fact, this learning objective was adapted from the Engineering is Elementary (EiE) curriculum designed for elementary level children (Cunningham, 2009) and was tested in this study with preschool children. Similarly, the findings indicated that those children who were able to give examples of technologies produced in different fields of engineering when they were reminded of the names of these fields were older than the others (72 months and 73 months). Therefore, this finding can be interpreted as this learning objective might be more appropriate for children at elementary level than for preschool children.

The last contribution to the children within the knowledge dimension was related to the children's comprehension of the fact that everyone could be an engineer and/or think like an engineer. The findings indicated that the EDCPI contributed to the change in the opinions of some children who, before the intervention, thought that girls could not be engineers. In addition, prior to the intervention, the children did not even know what an engineer did, yet the findings indicated that after the intervention, the children could give examples of situations where they could envision themselves as an engineer. This finding shows that EDCPI contributes to children's perception of themselves having the potential to engineer (English, 2018; Raven et al., 2018), to see engineering as a part of daily life (Cunningham & Higgins, 2015), and to understand that every person possessing different characteristics can be an engineer (Cunningham, 2009).

In summary, the findings of the present study showed that EDCPI enabled many of the learning objectives in the knowledge dimension to be achieved and, thus, made many contributions to children’s knowledge of engineering and technology. Indeed, EDCPI enabled children to develop an understanding of the meaning of engineering and technology and the importance of these two disciplines for our world and humanity. In addition, EDCPI contributed to children's understanding that engineering is effective in many different aspects of human life, that everyone can think like an engineer regardless of gender, and that engineering is a part of our daily lives. On the other hand, two different implementations of the curriculum showed that one learning objective and two indicators might not be suitable for children in this age group or might not be reached through EDCPI. These were defining technology, providing examples of what engineers do in different fields, and explaining the effect of engineering and technology on the world and society. In brief, although these objectives and indicators were designed based on the literature, they were not observed in the present study. Therefore, they were removed from the final prototype of the EDCPI.

5.2.2 Engineering-related Skills

In addition to the knowledge-related skills, the EDCPI also included some skills-related learning objectives. As aforementioned, the first prototype of these learning objectives was revised throughout the iterations of the study. The first five of these learning objectives were directed towards EDP, and the other two aimed at demonstrating science and mathematics knowledge and skills during the EDP. In fact, this study is based on the idea that preschool children possess these engineering skills naturally (Christenson & James, 2015; Dorie et al., 2014; English, 2018; Meeteren & Zan, 2010; Tippett & Milford, 2017), but that these skills can be supported through engineering education with parental involvement (Smetana et al., 2012). In fact, studies in the relevant literature provide evidence that engineering thinking and skills can even be demonstrated by children younger than preschoolers (Draper & Wood, 2017; Stone-MacDonald et al., 2015). The EDCPI in the current study aimed to make these skills of preschool children visible and support them with the help of parents. The findings reflected that the preschool children were able to successfully engage in the EDP, which included four main steps. In fact, the findings of the try-out study revealed that all the skills-related learning objectives of the EDCPI were observed during the implementation of the

EDCPI. On the other hand, it was not possible to say the same thing for the micro-evaluation. In fact, the findings which the micro-evaluation yielded revealed that excessive interference with the parents left children’s engineering skills in the shade. Similar findings can be found in the literature (Beal & Bers, 2006). However, as observed in most of the parents in the try-out, when this excessive intervention was replaced by parental scaffolding, children could demonstrate and develop these skills. In fact, when the scores obtained from the observation forms were examined, it was observed that children scored increasingly higher in the skills dimension during the implementation of the first four activities of the curriculum. The findings also showed that children demonstrated these skills gradually independently of their parents. All these findings are in line with the findings of the literature that preschool children are able to experience EDP effectively and produce effective solutions to design problems under some constraints (Bagiati & Evangelou, 2016; Davis et al., 2017; Gold et al., 2015; Malone et al., 2018; Meeteren & Zan, 2010; Torres-Crespo et al., 2014).

The findings of the current study revealed that EDCPI made contributions to preschool children's not only engineering skills but also science and mathematics knowledge and skills. In fact, the sixth learning objective related to skills was related to applying knowledge and skills in mathematics to the engineering problems. The findings revealed that during their design process, children benefited from their knowledge and skills of some key mathematical concepts, such as object counting, addition, subtraction, and fractions. In fact, children used verbal counting skills when measuring the dimensions of the roof by means of a ruler or a tape measure, and object counting skills during operations and counting how many of the materials they would need to build a bridge suitable for the length of the river. They experienced one-to-one correspondence while trying to construct equal-length feet onto the bridge they designed, and they experienced the balance while the bridge collapsed since it couldn't carry the weight of the turtle. Similarly, the findings indicated that children utilized their knowledge and skills of geometry, measurement, and spatial thinking during the EDP. For example, they measured the height of the parrot’s house to design an appropriate elevator, measured the length of the bridge by using nonstandard tools, talked about the geometric shapes of the roofs, imagined the problems, reflected these images on their plans by considering the spatial relationships, transformed their plans to the three-dimensional models, and used the data obtained from their measurements to create their designs. All these findings related to mathematical knowledge and skills are parallel to the findings of Bagiati (2011), which showed that preschool children demonstrated knowledge regarding key mathematical concepts, such as arithmetic, geometry, spatial concepts, scale and ratio during their engineering activities.

The final skill-related learning objective of the EDCPI was the utilization of science-related knowledge and skills during the EDP. The findings revealed that the EDCPI provided preschool children with experiences regarding some overlapping concepts. Indeed, as children tested their designs, they focused on the causal relationship underlying the events and developed their designs accordingly. They designed different systems to move marbles to the parrot’s house and to push the parrot’s car to the mechanic. They also focused on the function of different parts of the system they designed while explaining their plans. They discovered that raindrops would not accumulate on an inclining roof and a filter system made of plastic would not deteriorate when wet. Thus, they focused on the structure-function relationship. Similarly, children experienced some core components related to physical science during the implementation of the curriculum. For example, children explored different types of matters (e.g. plastic, wood, metal) and focused on their properties (e.g. hardness, softness, strength, size, waterproofness). They experienced forces and motion, as well as the effect of force and incline on the motion as they tried to push the parrot's car to the mechanic with a system that would be activated by a force applied by a marble (NRC, 2012). In addition to these, the children had the opportunity to experience many concepts such as buoyancy, simple machines, balance, incline, and speed, which they will encounter in their future school life and develop their designs based on these experiences. In fact, as defended in the relevant literature, findings of this study revealed that early engineering made most of the science-related concepts concrete for preschool children and enabled them to experience these concepts in a realistic context (Draper & Wood, 2017; Raven et al., 2018; Stone-MacDonald et al., 2015). These findings of the current study reflect the nature of engineering, which is based on the use of science and mathematics knowledge in engineering problems and provides a meaningful context for children to integrate all STEM disciplines in a holistic way.

To sum up, the findings of the current study revealed that all the objectives and indicators of the EDCPI under the skills dimension were observed during the implementation of the curriculum. In other words, as other experimental studies in the relevant literature (Bagiati & Evangelou, 2016; Cunningham et al., 2018; Elkin et al., 2018), the findings of this study indicated that preschool children were skilled in identifying the problem, producing ideas for solutions by considering various constructions, testing their solutions, and improving them in the light of testing results. The findings of the current study were also consistent with the finding reported by Purzer and Douglas (2018) that young children could even handle complicated problems and produce possible solutions when the needed support and opportunity were given. Indeed, the findings showed that when their engineering-related skills and natural curiosity leading to their science-related learnings (Conezio & French, 2002) were supported by their parents, preschool children became more willing towards and active in exploring, experiencing and producing solutions to the problems.

5.2.3 Engineering-related Dispositions

EDCPI also includes some learning objectives related to the dispositions of children during EDP. As mentioned in the previous chapters, children's dispositions during the EDP in this study were observed within the scope of four thinking skills. During the implementation of each of the EDCPI activities, the occurrence of the relevant thinking skill was observed. The first thinking skill was curious thinking. The findings indicated that the most frequently observed objectives were showing interest in learning new knowledge and experiencing new things and making observations and asking questions regarding the observable events. In fact, preschool children's desire to explore and learn is the main source of motivation in their journey to make the world meaningful, and they satisfy their curiosity by observing the events and experiencing new things for themselves (Conezio & French, 2002). Therefore, this finding is not surprising for people working with preschool children. On the other hand, benefiting from different resources in the exploration of the answers to the questions was not observed during the implementation of the curriculum. This may have been due to the fact that although it was a preschool classroom, the educational environment where the try-out was implemented was not the children's own classroom environment. In other words, since children were not in their classrooms, they might not have suggested the use of available resources such as books and computers in the classroom.

The second thinking skill focused on in the EDCPI was persistent thinking. According to the findings obtained from the second activity, all the children demonstrated the skill of repetitive testing of their designs until they solved the problem. Besides, most of them designed a plan and followed it while trying to solve the problem, continued to plan and did not stop following their aim until they solved the problem. All these findings revealed children's perseverance during the EDP and were in parallel with the findings of the studies in the literature focusing on children's engineering habits of minds (EHM) (Lippard et al., 2018; NAE, 2009; Van Meeteren, 2018). Findings also showed that as children experienced engineering, their determination to solve the problem and their effort to test and improve their designs increased. In a similar vein, Meeteren and Zan (2010) found that as long as children gained experience while engineering their ramps, their persistence and self-efficacy improved. On the other hand, findings revealed that the learning objective which was related to asking for help in the case of encountering a problem was not observed during the implementation of the second activity.

The third thinking skill was flexible thinking. The findings indicated that all the children suggested different ways of solving the problem presented to them in the context of the third activity, and they represented their ideas for solutions in different ways, such as sketching, modeling, and/or verbal expression. In their study, Lippard et al. (2018) observed preschool children’s daily activities in terms of the occurrence of EHM. Their observations revealed that children rarely verbalized the problems that they tried to solve and their alternative solution ideas when they dealt with material-based problems during their daily activities. On the other hand, the findings of the current study revealed that when the children were included in the EDP through such a curriculum, they were able to express both problems and their alternative ideas in various ways, such as verbal expression and plan. In addition, the findings revealed that children also observed other groups' solution process and were inspired by each other’s ideas for solutions, and they were open especially to their parents’ suggestions during the problem-solving process. This finding signifies the fact that preschool children consider new and different viewpoints as well as their openness in forecasting and planning (Stone-MacDonald et al., 2015). The findings also indicated that none of the children resorted to different sources, such as videos or pictures available on the Internet, during the problem-solving process, or books that might be available in the classroom. As mentioned earlier, this may be due to the fact that the implementation was not carried out in the children's own classroom. In fact, children could also access information by using their parents' mobile phones. However, in the training given before the implementation, the parents were asked to mute the mobile phones during the activities and keep their phones in their bags. For this reason, the parents may never have thought of using their phones for information purposes and of giving or offering them to their children. Besides, none of the children had made such a request.

Another thinking skill observed in this study was reflective thinking. The findings indicated that all the children documented their own experiences and thoughts. In fact, drawing a plan and constructing a model reflecting the proposed solution were components of the EDP cycle experienced in the EDCPI activities and enabled children to document their experiences and thoughts. Children used these documents both to explain solution ideas to their teachers and parents and to share their designs with other groups. The findings also revealed that talking about the experiences to evaluate and understand them, remembering the personal experiences and the sequence of these experiences through adult support, and using the knowledge of daily experiences in the new contexts were the other most frequently observed learning objectives. As Van Meeteren (2018) emphasized, the documentation enabled children to reconsider their learning process and to critique their work. On the other hand, the learning objective as regards supporting thoughts with evidence was not observed throughout the fourth activity.

The focus of the last activity of the EDCPI was collaborative thinking. The findings revealed that children had some trouble in collaborating with their peers during this activity. In fact, it was observed that the vast majority of children accepted the idea that other people might have different ideas from themselves and waited for their turn when working on a task. Besides, some of the children also interacted with their parents and the other members of the group in order to coordinate the roles and to collaborate on the task. On the other hand, the learning objectives of understanding the group members' emotional reactions and their reasons and of showing interest in the feelings of other group members were not observed. Moreover, the findings showed that some children did not communicate with their peers in the same group, and some of them did not want to share the materials with the other children in their group. This finding conflicts with the findings of other studies in early engineering literature that indicate children's collaborative work during the EDP (e.g. Bagiati & Evangelou, 2016; Van Meeteren & Zan, 2010). In group work, the group's efforts are fostered by diverse abilities and thinking processes (Ashbrook & Nellor, 2015). Moreover, as Cunningham and Higgins (2015) emphasized, working effectively in groups helps children to designate stronger solutions and to learn more effectively. Collaboration enables children to recognize that when they work with other people, they can produce a wider variety of ideas. Contrary to the studies in the relevant literature, in the fifth activity of the EDCPI, there was cooperation among not only children but also parent-child groups. Parents were expected to scaffold children who were in conflict and share materials and to play a mediator role in establishing interaction among children (Kail, 2016). On the other hand, in this activity, collaborating with a peer and with this child's parent might have been a challenge for some children, while, on the other hand, providing a more effective experience for some children. Besides, preschoolers mostly tend to cooperate with their peers. However, some of them show persistence in individual activities and are less willing towards collaborative play (Stone-MacDonald et al., 2015). Similarly, some of the participant children in the current study may have been more interested in individual activities and felt more comfortable while working alone or only with their parents. The teachers' statement that some of the children have difficulties working cooperatively in their classroom activities also supports this finding. In fact, as Stone-MacDonald et al. (2015) highlighted, preschoolers might need repetitive opportunities to work collaboratively with their peers. Therefore, as in the fifth activity, some of the other activities in the EDCPI might also be carried out in groups while teachers implement the curriculum in their classrooms.

To conclude, the findings of the study showed that children demonstrated most of the objectives of the five thinking skills, even if each thinking skill was observed only for one activity. The unobserved objectives were about using the resources in the problem-solving process and providing the idea with evidence. On the other hand, as Bagiati (2011) emphasizes, dispositions require long-term observation, so it is not possible to comment on whether children have these thinking skills by observing them during only one activity. In a similar vein, it is also not possible to foresee whether these thinking skills were reached through the EDCPI. Therefore, the findings from this study were only interpreted as evidence that thinking skills could be demonstrated by children in this age group during the learning activities within the proposed curriculum. In the following section, the findings on the feelings dimension are discussed under the guidance of relevant literature.

5.2.4 Engineering-related Feelings

The last learning dimension of EDCPI is feelings. Findings indicated that mostly positive feelings were demonstrated by children throughout the implementation of the curriculum. It was frequently observed that children were pleased to design solutions to various engineering problems with open-ended materials and also willing to participate in engineering activities. Similarly, in her study, Bagiati (2011) found that being interested in engineering activities, being willing to participate in and spend time on engineering activities and being pleased with resources (e.g. materials) were among the most frequently observed feelings of preschoolers. Besides, Akgündüz and Akpınar (2018) found that preschool children were motivated and a positive attitude toward engineering-based STEM activities. In fact, in a developmentally appropriate engineering education, engineering becomes a means for children to learn about the world we live in and how this world works (Van Meeteren, 2018) and provides them with meaningful and hands-on learning experiences (English, 2018). These characteristics can be the source of the willingness and satisfaction of preschool children to participate in engineering activities. In a similar vein, open-ended materials (also called loose parts) unleash children's creativity and imagination, improve their inventiveness, and inspire them (Neill, 2013). Therefore, during the engineering activities, engaging with open-ended materials that not only enabled children to express their creativity and inventiveness, but were also inexpensive and accessible might have motivated them (Cunningham & Higgins, 2015).

The findings also showed that children were pleased with working with their parents during the engineering activities. Bagiati (2011) included parents in her/his study through home-based involvement and by inviting some parents who were engineers to talk to children about their profession. In parallel with the current study, Bagiati (2011) observed children’s satisfaction with the involvement of their parents in their engineering education process. In fact, it was seen that children working in collaboration with their parents at home shared this collaboration experience with other children in the class with proud and enthusiasm. In another study, parents and preschoolers came together to solve the problem of wooden fences that constrained them from seeing what was happening on the other side of the playground. In the study, when the children were asked how their parents could help them, their answers showed how willing they were to work with their parents (Weatherly, Oleson, & Kistner, 2017). All these findings indicate that children are happy to see their parents at school and to cooperate with their parents.

As aforementioned, during the implementation process of the EDCPI, negative feelings were also observed. One of these negative feelings was boredom, which was observed from time to time as the child left the activity and engaged in other things. As parents pointed out, the reason for this feeling could be attributed to the child's distractions due to the stimuli in the classroom. In fact, as aforementioned, the learning environment was not the children's own classroom. Even if most of the transportable materials were removed from the classroom before the implementation of each activity, there were also some unremovable items. One of them was the tree-shaped reading corner in one corner of the classroom. The children wanted to go to this corner from time to time and spend time there. One of the activities where distraction was more frequent was the last activity. In this activity, as mentioned earlier, children worked in groups with other parents and children. During the collaborative work, it was observed that some of the children remained more passive in terms of generating and experimenting with ideas or trying to form a system on their own compared to their peers in the other group. This may be interpreted as the need for some children to further collaborate, exchange ideas, and team-up by means of activities in which they could collaborate.

Another negative feeling observed during the process was frustration due to the failure of the proposed solution. This feeling was observed in the first weeks of the process and disappeared over time. As Cunningham and Higgins (2015) emphasized, failure is an essential part of engineering and, thanks to the iterative nature of engineering, it is always possible to improve the design. Failure in engineering encourages the child to think about the design, give the child the chance to reason about why the design does not work and provide information on how to improve the design (Ashbrook & Nellor, 2015; Cunningham & Higgins, 2015). As it is emphasized that EDP is a flexible process, the child understands that failure is an expected condition in the process of continuous improvement and success. Moreover, coping with the frustration stemming from the failures enables preschoolers to develop emotionally and to be persistent in reaching success (Davis et al., 2017). In a similar vein, in the current study, frustration disappeared as children observed that failure was part of the process, unsuccessful attempts were an opportunity to generate new ideas, and in the event of failure there was a chance to improve the design and try again and again.

In summary, based on these findings, it can be said that preschool children are pleased to experience curriculum activities, cooperate with parents and work with open-ended materials. On the other hand, children rarely experienced negative feelings such as boredom and frustration during the practice. Based on these findings, it can be said that EDCPI has many contributions that can support the emotional development of children in addition to the gains in knowledge, skills, and disposition. All these findings indicate that EDCPI provides children with fun and an enjoyable learning process. EDCPI has made some contributions not only to children but also to parents. In the following section, these contributions are discussed in the light of the relevant literature.

5.3 Contributions of the EDCPI to the Parents

In recent years, with the growing interest to introduce engineering to children, prior to their pre-college years, as a career path and field of work , the role of parents and their involvement in their children's engineering education process have tried to be understood by researchers (Bagiati et al., 2011; Yun et al., 2010). According to studies, parents may serve as a guide for their children in their engineering thinking. In fact, from very younger ages until their high school years, parents can be influential in their children's attitudes towards engineering and can motivate their children to choose engineering as a career field in various ways depending on their developmental stages (Dorie et al., 2014). By taking into consideration these key roles that parents can play in their children's engineering education and the importance of their partnership in this process, in the present study, an engineering design curriculum based on for PI in ECE was developed. The findings obtained within the current study showed that the designed and developed curriculum also provided parents with a wide variety of contributions. It is possible to address these contributions in the context of parent-related learning objectives of EDCPI.

The findings revealed that EDCPI provided parents with a more comprehensive understanding of engineering and the work of engineers. In fact, prior to the intervention, parents defined engineering as producing new things, inspecting the existing technologies, inventing, and designing. On the other hand, the findings revealed that, subsequent to the intervention, parents mentioned the ultimate goal of engineering to be producing solutions to certain human problems and needs (NRC, 2012) in their definitions of engineering. Besides, as Dorie and Cardella (2014) emphasized, parents' understanding, and knowledge of engineering could influence their children's attitude to and interest in engineering. Therefore, the EDCPI in the current study also aimed to improve parents' understanding of the effects of engineering on human life. The findings revealed that parents had already been aware of both positive and negative influences of engineering. However, after the intervention, their examples for explaining the effects of engineering included examples from daily life. Accordingly, it can be deduced that EDCPI contributed to parents' awareness of the place and importance of engineering in our daily life. In their study, Yun et al. (2010) investigated parents' awareness of engineering, and the findings of their pilot study revealed that parents had a positive attitude towards engineering but limited knowledge of engineering. At this point, based on the findings of the present study, it can be said that EDCPI is an effective intervention in developing parents' knowledge and understanding of engineering and its impact on our lives.

The findings of the current study also revealed that EDCPI contributed to parents' awareness of the importance of engineering in early childhood and provided them with a more comprehensive perspective in this subject. Subsequent to the intervention, parents believed that engineering education could provide their children with more hands-on, real-life connected, and enjoyable learning experiences. According to the parents, EDCPI contributed to their children's creativity, imagination, persistence, problem-solving skills, knowledge of engineering products used in daily life, knowledge of new concepts, and motor development. In parallel with the findings of the current study, Bagiati et al. (2011) found that most of the parents believed that engineering would contribute to their children's cognitive development and generic skills. Parents with an understanding of what kinds of contributions that exposure to engineering from younger ages could make to their children might be more supportive in their children's engineering education process.

According to the findings, another contribution of EDCPI to parents was related to parents' understanding of PI in education. In fact, parents' initial ideas for PI were that it was to conduct activities with children, support school learning, and learn about what was happening at school. The findings revealed that, after the intervention, parents approached PI from a more comprehensive perspective and defined PI as carrying out some activities with children with the purpose of entertainment or education, supporting the child through questions, and collaborating with the child. The findings also indicated that the intervention contributed to the parents' feelings that their children were valued in engineering education and understanding that they had important roles in this process.

As for engineering education, research revealed that even parents who were engineers experienced some difficulty in sharing their knowledge about their profession with their children (Dorie, Cardella, & Svarovsky, 2015). On the other hand, one of the important factors to raise awareness and interest of children in engineering is to understand how parents can support their children's knowledge and interest in this area (Dorie et al., 2014). In addition, as Hoover-Dempsey and Sandler (2005) highlight, parents' beliefs about their role and responsibilities in their children's education are effective in their decisions concerning PI. As regards EDCPI, therefore, it was important to help parents understand what their role could be in their children's engineering education process. The findings revealed that parents' initial knowledge about their role in fostering their children's engineering education was limited. On the other hand, after the intervention, parents touched on various ways of supporting children's engineering-related learning both inside and outside of the school setting. Indeed, parents pointed out that they could support their children's learning in engineering in various ways, such as providing them with scaffolding, talking with the child about engineering and technology, providing children with open-ended materials, and giving the child the opportunity for trial and error. Moreover, parents regarded EDCPI as an effective PI activity, which enabled them to know their children more closely, to become involved in the learning process, to think and ask questions, and to learn alternative ways of how and what could be taught to children. This finding signified that EDCPI contributed to the role construction of parents which was an important motivator for parents to involvement in their children's education (Hoover-Dempsey & Sandler, 2005). As English (2018) emphasized, parents need to be aware of how children's skills can be reinforced and developed to lay the foundations of engineering education. Parents with this awareness are likely to support their children's learning in engineering and STEM both at and outside school (Hoover-Dempsey & Sandler, 1995).

Another parent-related objective of the EDCPI was to support parents in making some changes in their home environment to support their children's engineering education. The findings indicated that most of the parents had not made any changes in their home environment yet, but some of them had started to collect recyclable materials to use during engineering activities. The findings also revealed that EDCPI enabled parents to gain a new perspective on the usage of open-ended materials. In fact, after the intervention, many parents stated that they were surprised when they saw that their children created useful designs from open-ended materials and that they had never before thought that open-ended materials could be used for educational purposes. As aforementioned, the usage of inexpensive and easily accessible materials in the engineering education process could encourage parents to continue their support in their children's engineering learning through home-based involvement (Cunningham & Higgins, 2015). Therefore, this contribution of EDCPI to the parents in the usages of open-ended materials can also be interpreted as an important contribution to the sustainability of PI in early engineering.

EDCPI also aimed to improve parents' self-efficacy in working with their children on engineering-related activities. Findings indicate that most of the parents felt sufficient in this issue both before and after the intervention. On the other hand, after the intervention, there were some parents who felt that they might be unable to continue their engineering learning at home, or they might not have time to continue supporting engineering education at home. As in many other studies in the literature, in the current study, the parents' context of daily life appeared as a barrier to PI (Ho & Kwong, 2013; Hornby & Lafaele, 2011). In fact, parents stated that they might remain limited in the supporting engineering activities at home for some reasons arising from their life contexts (e.g. having more than one child, workload). For this and many other reasons, most of the parents stated that they would prefer to support their children's engineering education in the school environment and under the guidance of teachers through the implementation of such a curriculum. In parallel with these findings, Smetana et al. (2012) remark that present day's busy parents are willing to participate in educational activities together with their children and are pleased about the convenience of participating in an activity where all the education process and materials are organized and provided by experts. Therefore, based on the findings of the present study, it can be deduced that parents need such type of engineering activities to be implemented in the school environment and under teacher guidance to support engineering and science education of their preschool children.

Finally, the EDCPI aimed to make parents monitor and aware of their children's progress in engineering. The findings revealed that, after the intervention, most of the parents became more aware of their children's engineering-related knowledge and skills and they monitored their children's progress in this field. In fact, most parents reported that they observed some changes in their children, which might be related to the intervention, such as constructing new designs at home as well, keeping on trying the designs constructed in activities at home, showing and telling their experiences and their designs to others.

To conclude, most of the learning objectives related to the parents were achieved through EDCPI. The findings revealed that the EDCPI and the parental training provided within the scope of the study made a wide variety of contributions to the parents, such as improving parents' knowledge and understanding of engineering, the role and importance of the early engineering, the importance and role of parents in children's engineering education, and the ways of guiding preschoolers' learning in engineering and STEM. As McClure et al. (2017) emphasized, when parents are supported in the matter of how they can reinforce their children's knowledge and skills in engineering and STEM, they can provide developmentally appropriate scaffolding. Findings obtained from the current study signified that EDCPI may be an effective way of supporting parents to reinforce their children's learning. In the following section, contributions of the EDCPI to the preschool teachers, who were the other participants of the study, are discussed.

5.4 Contributions of the EDCPI to the Teachers

Preschool teachers, as collaborators of the design and development process of the EDCPI (Design-Based Research Collective, 2003), made important contributions to the study. In a similar vein, EDCPI also contributed to the participant teachers. According to the findings of the current study, the EDCPI contributed to preschool teachers' knowledge of engineering and STEM in early childhood. In fact, prior to the intervention, preschool teachers had considered engineering in early childhood as solely activities performed by means of construction and plug-in toys. Similarly, their knowledge of STEM was limited to sample activities on the Internet. This finding is not surprising because engineering and STEM are a new field of early childhood education literature, and the majority of preschool teachers do not have any education or experience in this field. On the other hand, as Cunningham (2009) emphasizes, assisting children in the improvement of their understanding and skills necessitates teachers to comprehend, feel confident in and teach the subject. Therefore, efforts to bring engineering education into the classrooms requires teachers to be provided with both sources and professional development opportunities in order to help them learn how to teach engineering. Similarly, in the current study, findings showed EDCPI contributed to preschool teachers by enabling them to gain a broader perspective towards early engineering and STEM. Subsequent to the intervention, teachers believed that they should present some scientific concepts to the children through concrete experiences, that they should lay the foundation for future learnings by raising students' awareness, and that they should enable children to connect the learnings with real life. Moreover, EDCPI motivated teachers to integrate engineering and STEM into their classrooms. This finding is parallel with the studies advocating that the importance and appropriateness of STEM and its integration into ECE (Ata-Aktürk et al., 2017; Davis et al., 2017; Moomaw & Davis, 2010; Park, Dimitrov, Patterson, & Park, 2017). In fact, as claimed by Bagiati and Evangelou (2015), such a positive attitude of the preschool teachers toward engineering and STEM was very important in this study, in which preschool teachers were the collaborators of the design and development of the curriculum.

The findings indicated that as preschool teachers became engaged in the curriculum development and implementation process, they gained the knowledge and experience about how engineering looks like in an early childhood classroom. Therefore, the EDCPI provided contributions to their self-confidence and professional development. In parallel with this finding, DeJarnette (2018) prepared a workshop aiming at providing preschool teachers with professional development in Science, Technology, Engineering, Art, and Math (STEAM) and revealed that teachers' self-efficacy in planning and implementing STEAM activities increased after the workshop. On the other hand, the researcher reported that none of the participant preschool teachers implemented any STEAM activity in the following two-month period. Similarly, the current study provided teachers with a certain degree of professional development and self-efficacy for engineering in the preschool period, but it is in the hands of the teachers to maintain and improve it.

The findings revealed that the EDCPI provided teachers with a new perspective in not only engineering but also in science education in early childhood. In fact, teachers pointed out that they understood that science education should provide preschoolers with meaningful and concrete experiences, observation, active involvement, and hands-on learning. In fact, the informal interviews conducted with teachers before the implementation of the activities indicated that teachers had some hesitations regarding whether the children were able to comprehend the physical science concepts presented to them. Similarly, Park et al. (2017) found that some of the preschool teachers believed that scientific concepts were abstract to be understood by preschoolers and that children did not have a science-related background when they came into preschool. On the other hand, the informal interviews conducted with the teachers after the implementation of each activity and the teacher journals indicated that EDCPI contributed to teachers' understanding of preschool children's science-related learning. In fact, after the intervention, teachers reported that they noticed preschoolers could understand scientific concepts when these concepts were presented in concrete and meaningful experiences provided by engineering. As in Bustamente, Greenfield, and Nayfeld (2018)'s study, engineering and science might become favorite contents for preschool teachers, after they observed their students' excitement towards and learning and active involvement in the experiences on these fields.

The last contribution of the EDCPI to the teachers was related to PI. According to the findings of the current study, the EDCPI provided preschool teachers with an alternative way of PI, and motivated teachers to carry out such an engineering activity with the involvement of parents in their classrooms. In fact, as Peterson (2017) emphasized, teachers can involve parents in STEM education in a formal and/or informal manner. All that is needed is a telephone call and a well-planned learning process. Such a learning process in which children are engaged together with their parents is also a wonderful way for teachers to learn together with children and parents (Smetana et al., 2012).

5.5 Implications for Educational Practices

The present study was carried out to design and develop an engineering design curriculum as a PI activity for preschool classrooms to enhance preschoolers' learning in engineering and STEM. Hence, two main outputs of this DBR were the engineering design curriculum, which was also proposed as an alternative way of PI in ECE, and the main characteristics of this curriculum. Moreover, possible contributions of this engineering design curriculum to the preschool children, preschool teachers, and parents were other important outputs. In consideration of the obtained findings, it is possible to discuss some implications of the current study for preschool teachers, school administrators, parents, curriculum developers, and teacher educators. Following are some implications of this study for educational practitioners are discussed.

In this design-based study, a preschool engineering design curriculum based on STEM and implemented with the involvement of the parents was developed. The findings of the study revealed that engineering education could be effectively implemented in preschool classrooms with the involvement of the parents into the education process. In other words, the findings revealed that EDCPI is a usable and effective curriculum to support preschool children's learning in engineering and STEM and to provide parents with both the knowledge of early childhood engineering education and of the ways of supporting their children's engineering learning. EDCPI also enabled preschool teachers to help children to identify engineering examples at school, within the home environment, and in everyday life and to involve preschool children and their parents in the implementation of EDP in diverse contexts (Smetana et al., 2012). The findings of the current study indicated that through such a curriculum, it is possible to enhance preschool children's knowledge and skills in engineering, enhance their knowledge and understanding of some mathematics and science-related concepts and motivate children to maintain engineering at home environment. Similarly, the findings indicated that such a curriculum could foster parents' understanding of engineering and of its importance in our lives. EDCPI could also provide parents with the knowledge of EEE and how they could support it. In addition to the contributions to children and parents, the findings also showed that EDCPI provided some contributions to teachers in terms of educational practice. In fact, findings revealed that EDCPI was a motivating and effective curriculum for teachers to bring engineering and STEM into their classrooms and to involve families in the children's engineering education process. In the light of all these findings, it can be inferred that EDCPI can be applied in preschool classrooms as an effective and alternative way of PI to promote preschoolers' learning in engineering and other fields of STEM. EDCPI can provide preschool teachers who want to incorporate STEM into their classroom with the guidance they need and can gain parents' support in the process. In the light of all these findings, it can be inferred that EDCPI can be applied in preschool classrooms as an effective and alternative way of PI to promote preschoolers' learning in engineering and other fields of STEM.

An important implication related to the usage of the designed and developed curriculum is its flexibility and adaptability. As mentioned in the design principles, the findings revealed that EDCPI was a curriculum allowing preschool teachers to adapt the content to the needs and characteristics of the children and parents in their classroom. In fact, EDCPI provides preschool teachers with sample engineering activities tested and revised by means of classroom implementations and formative evaluation. Therefore, teachers can implement EDCPI activities by adapting them into their classrooms or they can design similar engineering activities involving parents into the education process for their classrooms by referencing the EDCPI activity templates. EDCPI learning objective and indicators identified by means of a comprehensive literature review and verified by classroom implementations can provide preschool teachers with a frame for EEE and thus shed light on their implementations. In this way, preschool teachers can design similar PI activities for their classrooms by referencing these learning objectives and indicators. Before implementing such an engineering design curriculum including PI, preschool teachers can organize brief activities to be familiar with the parents and to enable parents to be familiar with each other. In addition, the findings of this study showed that a fruitful engineering education process could be provided with easy-to-access and low-cost materials in public schools. Therefore, the curricula can also be implemented by teachers in schools with limited opportunities only with the participation of parents and children and the use of available open-ended materials.

As mentioned earlier, EDCPI was designed and developed to be implemented outside the school curriculum to support preschool children's learning during the week. However, the design process that followed, the presentation of the design problems to the children in a developmentally appropriate way, and hands-on experiences to teach some scientific concepts to the children can also be useful resources for preschool teachers to design child-only engineering activities. Therefore, preschool children can experience EDP with their peers through the engineering activities designed by the teacher in an integrated way to the curriculum, and then they can have the opportunity to reinforce their learnings and collaborate with their parents at the weekends through the EDCPI.

In the relevant literature, it is possible to encounter studies revealing that some preschool teachers were of the belief that STEM was not developmentally appropriate in preschools (Park et al., 2017). Similarly, as Cunningham (2009) drew attention, some teachers might have a perception about engineering towards that it can be learned and performed solely by "super-smart" children. Similarly, in the current study, informal interviews with preschool teachers throughout the study revealed that teachers had some doubts about whether children could produce effective solutions to the engineering problems presented in the activities. On the other hand, it was not only the teachers who were hesitant about the children's performance in the activities. In fact, at the beginning of the curriculum implementations, families were hesitant that their children could experience great frustration if they could not produce a successful design. EDCPI has demonstrated that children can find solutions to even complex design problems when they are challenged in developmentally appropriate contexts and they can experience EDP in an effective way under the guidance of their parents. The findings showed that in time, children, like an engineer, were able to draw new learning opportunities from their failures, actively and willingly participate in the EDP, work in collaboration with their parents, and maintain their motivation for engineering at home. The findings also showed that teachers and parents who witnessed all these gains realized that preschool children could demonstrate their true potential when provided with appropriate guidance. Thus, as an intervention, such a curriculum can provide real classroom experiences that will help teachers and parents remove doubts that preschool children will not be successful in engineering and STEM activities or that STEM cannot be implemented in ECE.

Another implication of this study is about the role of parents in such a learning process. The study findings indicated that when parents provide appropriate guidance, they contributed to the child's learning in engineering and other STEM disciplines. On the other hand, findings of the study also pointed to the fact that excessive intervention by parents limited children's learning and prevented the achievement of the curriculum objectives. This finding reflects the crucial role of parental scaffolding in ECE environments to provide preschoolers with fruitful learning opportunities. Indeed, this study revealed that PI gains importance in such a learning environment when it was provided in the form of scaffolding. The findings also showed that after acquiring the theoretical knowledge of how to scaffold their children in parental training provided to them through such a curriculum, experiencing the learned strategies during the activities contributed to the parents in terms of their approach to the child. In other words, the implementation of EDCPI was an education process not only for children but also for their parents. On the other hand, within the scope of the present study, one and a half hours of training was given to the parents before the implementation process. In this training, parents were informed about STEM and engineering education in early childhood, EDP, the scaffolding strategy, and the role of parents in preschoolers' engineering education. The findings revealed that this training provided parents with knowledge of EEE and the scaffolding strategy, and some parents used their learnings during the activity implementations. However, some parents reflected their need for more support in the matter of how they can provide effective scaffolding in engineering. As McClure et al. (2017) emphasized, most parents have low self-efficacy in STEM subjects, but they are open to educational opportunities to be provided to them in these subjects. By considering this, an implication based on the findings of the present study could be that parents should be provided with a long-term education on engineering and STEM and provided with more examples of scaffolding in EDP.

The present study also includes some implications for parents in terms of supporting their children's engineering education inside and outside the school environment. The findings indicated that EDCPI provides parents with an understanding of how engineering looks like in the preschool period and how they could support it. Therefore, parents can implement the same or similar activities with their children within the home environment to support their science and engineering learning. Moreover, parents can also support their children's engineering learning at school by means of sample home-based PI activities included in the EDCPI. On the other hand, as the findings of the current study revealed, life context might be a barrier to PI at home. In the present study, the participating parents stated that through such an activity carried out at school, they could find the opportunity to spend quality time with their children within the intensity of daily life. Parents also said that this process provides them with the opportunity to get to know their children better and to recognize their children's strengths and weaknesses. By considering all these findings, it can be concluded that EDCPI can provide parents and children with a shared time period and a productive learning experience.

In addition to preschool teachers and parents, implications of the current study can be discussed in terms of school administrators. This study is based on the collaboration of participant school administrators, preschool teachers, and the researcher. The findings of the present study provide an example of how productive results can be achieved when partnerships are established between parents and schools. As Smetana et al. (2012) stressed, hosting such a PI activity provides schools with the opportunity to display their willingness to give priority to the up-to-date education approaches in curriculum, such as engineering and STEM, and to encourage students to obtain knowledge and skills required for this century's workforce. Thus, by encouraging and supporting the implementation of EDCPI in their schools, school administrators can make parents feel that they are welcomed in the school environment and they are valuable in the education of preschool children.

One of the most important stakeholders of this DBR process was the teachers. Findings obtained from the teachers revealed that EDCPI provided them with an understanding of engineering and STEM in early childhood and contributed to their professional development and motivation. Besides, the findings showed that teachers criticized themselves about their previous practices in science activities following the intervention. On the other hand, none of the participating teachers had any background in engineering and STEM education, and their knowledge of STEM was limited only to examples of activities they encountered in various sources. The current study indicated that teachers could not make sense of STEM because of lack of explanations about how children could be provided with concepts in activities in these resources or because STEM was shown to solely be science experiments. This finding indicates that preschool teachers need professional development to learn the nature of engineering and STEM and how to integrate them into their classroom. Such a professional development can be provided by experts in the field, in collaboration with MoNE, through workshops and in-service trainings. By means of such training, preschool teachers' awareness of current studies and practices carried out in this field in the world and in Turkey can be raised, and they can find the opportunity to acquire first-hand experience in EDP through the practices in which they try to solve various engineering problems. Such professional development opportunities should be prepared to provide preschool teachers with the knowledge and skills necessary to integrate and effectively implement STEM in their classroom. On the other hand, this finding can also point out the need for improvement in teacher education programs. In fact, STEM education, in which the understanding of all children becomes critical as a result of the technology revolution (McClure et al., 2017) and which is crucial for modern education (Kanematsu & Barry, 2016) has not been included in early childhood teacher education programs in Turkey yet (Higher Educational Council, 2018). On the other hand, as the findings of this study reflect, preschool teachers need to be well-educated in STEM education in order to guide their students who are "inventors and problem solvers of tomorrow" (McClure et al., 2017, p.10). Therefore, as touched upon in the STEM education report (TÜSİAD, 2017), there should be some improvements in teacher education to develop creative, innovative, analytical and critical thinking individuals with high problem-solving skills. In this regard, some courses focusing on early childhood STEM education can be added to the teacher education programs taught in education faculties. Within the scope of these courses, prospective teachers can acquire theoretical knowledge about STEM and reinforce this theoretical knowledge with the practices they will make in preschool classrooms. Furthermore, in these courses, pre-service preschool teachers can experience STEM-based engineering practices in which parents are involved, as in the current study.

The last implication of the study was related to the ECE curriculum developers. Even if the current ECE curriculum proposed by Turkish MoNE (2013) is convenient, integration of STEM, engineering and technology have a very limited place in the curriculum content (Ata-Aktürk et al, 2017). According to the findings obtained from the current study, when engineering education was implemented in a developmentally appropriate way, the preschool children could obtain knowledge of not only engineering but also science and mathematics-related concepts and gain skills in these fields. Many of these concepts and skills are among the objectives to be achieved in the current ECE curriculum. Furthermore, as evidenced by the findings, engineering education does not provide children with knowledge and skills solely for STEM disciplines. In fact, EDP, which is experienced in engineering education, is a process in which children exhibit their collaborative, flexible, persistent, curious and reflective thinking skills. All these skills are considered among 21st century skills in the literature (P21, 2016). The findings of this study also showed that children were able to demonstrate their creativity and inventiveness in the EDP and to share, to express themselves, to cope with negative emotions in the face of failure, and to turn unsuccessful attempts into learning opportunities. In other words, findings revealed that engineering education supports preschool children in terms of their cognitive, emotional, social, and motor development and in terms of their imagination and creativity. In all these respects, this study implies that engineering education in the preschool period is parallel with the current curriculum and that the current curriculum might be extended in terms of engineering-related learning objectives and indicators and sample activities.

To conclude, in line with the findings of the current study, it is possible to mention a wide variety of educational implications. These im

lications are discussed in this section in detail. Besides, this study also includes some limitations and proposes some recommendations for further studies to be conducted in the relevant field. These recommendations are discussed in the following section by also considering the limitations of this study.

5.6 Recommendations and Implications for Future Studies

In this study, the main aim was to design, improve, and evaluate a STEM-based engineering design curriculum for PI in ECE. In the previous sections, both the findings and the educational implications of the study were discussed. In this section, suggestions for future research are discussed with reference to the limitations of the study. First of all, due to some procedures related to permission for research in the city where the study was conducted and limitations of the study deriving from the limited number of teachers volunteering to participate in a five-week implementation, the final prototype of the EDCPI could not be tested. In fact, the formative evaluation of the final prototype of the EDCPI was performed through expert appraisal. Therefore, even if the intervention had been tested with a representative sample of the target user of the curriculum, it would not have been possible to mention actual practicality and effectiveness of the EDCPI within this study (van den Akker, 2010). Nevertheless, in the light of the obtained findings, the expected practicality of the design principles and the EDCPI and their possible contributions to the target users were asserted. Similarly, due to the nature of the qualitative research and it was required an in-depth observation throughout the implementation process, the number of the participant parent and children was limited in the current study. This number can be regarded as a limitation for such research aimed at curriculum development. In further studies, the final prototype of EDCPI and the resulting design principles can be tested through a try-out study again with a larger representative sample of the target users and in the target settings to test the actual effectiveness and practicality.

In the current study, learning in early childhood was addressed under four main dimensions in the light of the relevant literature, and one of these four dimensions was the dispositions. In the context of the current study, some thinking skills related to engineering (Stone-MacDonald et al., 2015) were observed within this dimension. In fact, each thinking skill was observed only during one activity and the children were evaluated in this thinking skill only through the indicators that they displayed in that activity. On the other hand, disposition refers to the tendency of demonstrating conscious, voluntary and frequent behavior for a purpose (Katz, 1993). Therefore, a long-term observation may be necessary to claim the existence of a disposition. These thinking skills can be observed for a longer period in future studies which could be conducted with preschool children; findings can shed light on whether these thinking skills can be considered as dispositions exhibited during engineering activities.

As mentioned earlier, for some reason, this study could not be applied in the classroom of the participating teachers and children. Although the class was largely purified of these factors, some environmental factors in the classroom (such as the garden shaped reading corner) have attracted children's attention and occasionally distracted their focus on activities. Further studies can be carried out in children's own classrooms or in an atelier free of irrelevant materials, in this way, it may be easier for children to maintain their attention.

The current study was structured on the design and development of a STEM-based early engineering design curriculum addressing to preschool children and their parents. Therefore, a STEM and PI-based engineering design curriculum in ECE and the main characteristics of such a curriculum are the outputs of the study. In other words, in the context of this study, a framework regarding the design and development of a STEM-based engineering design curriculum for providing with the involvement of parents into their children's education process and for enhancing preschool children's learning in engineering and STEM was practiced. Further studies can contribute to the improvement and evaluation of parental-involved EEE by utilizing this framework to validate and expand its other learning environments. In addition, eight parent-child groups participated in the micro-evaluation phase and five parent-child groups participated in the try-out phase of this study. According to the findings, teachers stated that it would be difficult to implement EDCPI in crowded classrooms and this could be a barrier to the implementation of this curriculum in their classrooms. In future studies, EDCPI can be implemented with the participation of more parent-child groups, and more comprehensive data can be obtained on whether the number of participants is a barrier. In addition, the findings of this study pointed out that engineering was a way for preschool children to enjoy the learning process and to obtain minds-on and hands-on learning experiences. Therefore, many learning objectives can be achieved when engineering is implemented not only as a PI event but also integrated into the classroom curriculum (Bagiati, 2011; Dubosarsky et al., 2018; Elkin et al., 2018; Tank et al., 2018). On the other hand, engineering in ECE settings is an area that is newly developing and in need of many experimental studies and curriculum development studies (English, 2018). Therefore, future studies can focus on curriculum development by collaborating with preschool teachers for the integration of engineering and engineering-based STEM into ECE settings. Moreover, in the current study, learning objectives and indicators were mostly focused on engineering and other STEM disciplines. On the other hand, a developmentally appropriate engineering education can also make a wide variety of contributions to preschool children in different developmental areas (Davis et al., 2017). Therefore, future studies can focus on the influences of EEE to preschoolers' development in different fields, such as cognitive, emotional, and social skills. Similarly, the effect of engineering on the development, creativity, future academic success and career choice of preschool children can be examined through longitudinal studies.

Finally, in the current study, children and their parents experienced EDP by collaborating with other parent-child groups only in one activity. The findings showed that some children had problems in working collaboratively. This may be related to children's difficulty in collaborating with other parents or individual characteristics. On the other hand, when different parent-child groups come together and worked together for longer periods of time, these problems can disappear and this can lead to many gains (Weatherly et al., 2017).

Hence, researchers who plan to study engineering education with PI can make observations on the collaboration in the child-only conditions and the collaboration in parental-involved conditions. In this way, it may be possible to obtain more comprehensive data on the dynamics that may have an impact on preschoolers' collaborative working skills and to make more valid comments on these factors.

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APPENDICES

Appendix A: Child Pre-Interview Questions

Çocuk Ön-Görüşme Soruları

1. Bildiğin meslekler var mı? Peki sen büyüdüğünde ne olmak istiyorsun?

2. Elimde bazı kartlar var. Bu kartları sana sırasıyla göstereceğim. Sen de bana gösterdiğim kartta resmini gördüğün insanın hangi mesleği yaptığını söyler misin?

3. Mühendisler ne yapar biliyor musun?

4. Sence mühendisler insanlara yarar sağlar mı?

5. Senin tanıdığın bir mühendis var mı? (Evetse: Tanıdığın kişi ne mühendisi? Kadın mı erkek mi?). Kadınlar da erkekler de mühendis olabilir mi? Mesela bazı çöp kutularında pedal var ve biz ona bastığımızda çöp kutusunun kapağı açılıyor ya, işte onu bir kadın mühendis icat etmiş. Peki senin hatırladığın başka hangi icatlar var? Onu kadın mühendis mi erkek mühendis mi geliştirmiş biliyor musun?

6. Peki sen ya da ailenden başka biri daha önce hiç mühendislik yaptınız mı? (Evetse) Neler yaptınız?

7. Peki teknolojinin ne demek olduğunu biliyor musun?

8. Sen daha önce hiç teknoloji gördün mü? Nerede gördün?

9. Sana bazı kartlar göstereceğim. Bu kartların üzerindeki resimleri incelemeni istiyorum. Bu kartlardaki resimlerden hangilerini mühendisler yapmış olabilir? Mühendislerin yaptıklarını sarı kutuya, diğerlerini de mavi kutuya koymanı istiyorum.

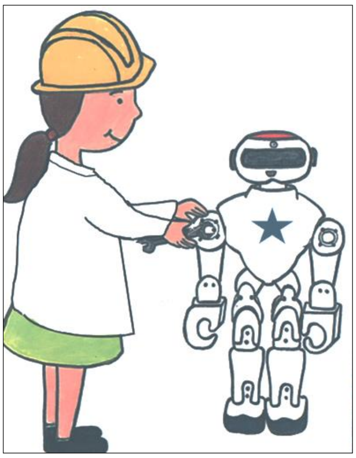
10. Neden sarı kutudakileri mühendislerin yapmış olabileceğini düşündün? Diğerlerini neden mühendisler yapmış olamaz?

Son olarak, çocuğa üzerinde mühendislik tasarım sürecinin adımlarına yönelik görsellerin yer aldığı 4 adet kart gösterilir. Çocuktan her bir resimdeki görseli yorumlaması bu resimleri olay sırasına göre sıralaması istenir.

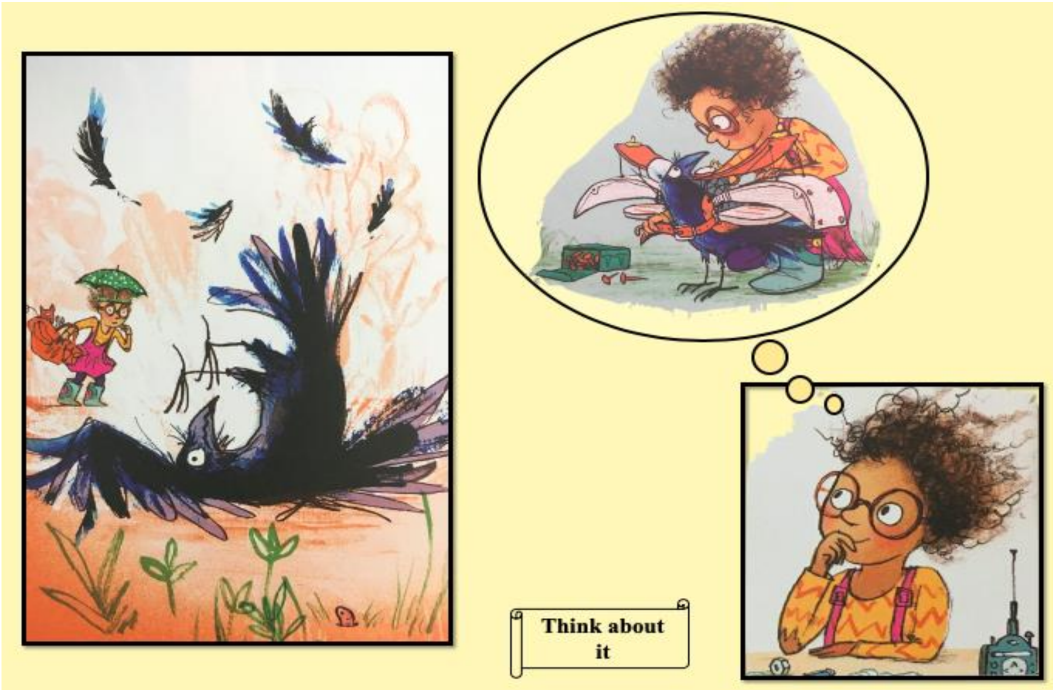
Appendix B: Cards Representing Different Professions

Meslekler Kartları




Appendix C: Cards Representing Engineering Design Process



Fix it

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Appendix D: Technology and Natural Object Pictures Used in the Child Interviews











Appendix E: Parent Pre-Interview Questions

Ebeveyn Ön-Görüşme Soruları

1. Kaç yaşındasınız?
2. Eğitim durumunuz (en son mezun olduğunuz okul) nedir?
3. Mesleğiniz nedir?
4. Eşinizin eğitim durumu (en son mezun olduğu okul) nedir?
5. Sizce mühendislik nedir?
6. Sizce mühendislik insan yaşamını etkiler mi?
   a. Olumlu yönde etkileri olabilir mi? Örnek verebilir misiniz?
   b. Peki olumsuz yönde etkileri olabilir mi? (Evetse) Örnek vererek açıklar mısınız?

7. Zaman zaman çocuklara baktığımızda uğraşlarını, oyunlarını ve yaptıklarını bazı mesleklere benzettiğimiz olur. Çocuğunuzu hiç mühendise benzettiğiniz oluyor mu?
   a. (Evetse) Ne gibi benzerlikler görüyorsunuz?

8. Çocuğunuzla daha önce hiç mühendislik hakkında konuştunuz mu?

9. Sizce çocuğunuzun şu anki sınıfında mühendislik eğitimi veriliyor mu?

10. Mühendisliğin çocuğunuzun sınıfında uygulanan eğitime dahil olmasını ister miydiniz? Yoksa çocuğunuz mühendislikle ilgili bilgi ve becerileri yüksek öğrenim sürecinde (tercih ederse) mi öğrenmeli?

11. Çocuğunuzun mühendislik eğitimi alması sizce önemli mi? Neden?
   a. Mühendislik eğitimi çocuğunuza ne kazandırabilir?

12. Çocuğunuz okul öncesi dönemde mühendislik ile ilgili bir eğitim alacak olsa, bu eğitimin içeriğinde nelerin olmasını isterdiniz?

13. Çocuğunuzun mühendislik eğitimi ile ilgili böyle bir etkinliğe davet edilmenizin nedeni sizce nedir? Böyle bir eğitim ortamına davet edilmek size nasıl hissettirdi?

14. Çocuğunuzun mühendislik eğitimi sürecine destek olabilmek için neler yapabilirsiniz?

15. Diyelim ki okuldan mühendisliğe yönelik çocuğunuzla birlikte yapmanız gereken ev ödevleri verildi. Bu ödevleri yaparken çocuğunuzu destekleyebilmek için;
   a. Yeterli bilgiye sahip hissediyor musunuz?
   b. Yeterli beceriye sahip hissediyor musunuz?
   c. Yeterli zamanınız var mı?
   d. Yeterli enerjiniz var mı?
   e. Yeterli isteğiniz var mı?

16. Çocuğunuzla birlikte daha önce hiç mühendislik yaptınız mı?

17. Mühendislik eğitimi aracılığıyla çocuğun başka alanlardaki (Fen, Teknoloji, Matematik, Türkçe, Sanat gibi) öğrenmeleri de desteklenebilir mi? Açıklar mısınız?

18. Diyelim ki çocuğunuza mühendislikle ilgili içerikler öğretildi, ev ortamınızın çocuğunuzun mühendislik eğitimini destekleyici (malzeme, çalışma alanı vb. açısından) olduğunu düşünüyor musunuz? Açıklar mısınız?

19. Sizin için bu etkinlikler sırasında çocuğunuzla birlikte başarıya ulaştığınızın göstergesi ne olabilir?

20. Sizce eğitimde aile katılımı nedir?

a. Neler eğitimde aile katılımı olarak düşünülebilir?

21. Sizce eğitimde aile katılımı gerekli midir? Neden?

22. Çocuğunuzun sınıfında daha önce hiç herhangi bir etkinliğe katıldınız mı?

23. Evde çocuğunuzun eğitimini desteklemek için neler yapıyorsunuz?

Appendix F: Teacher Pre-Interview Questions

Öğretmen Ön-Görüşme Soruları

1. Sizce mühendislik nedir?
2. Mühendis ne iş yapar?
3. Sizce mühendislik insan yaşamını etkiler mi?
    a. Olumlu yönde etkileri olabilir mi? Örnek verebilir misiniz?
    b. Peki olumsuz yönde etkileri olabilir mi? (Evetse) Örnek vererek açıklar mısınız?)
4. Zaman zaman çocuklara baktığımızda uğraşlarını, oyunlarını ve yaptıklarını bazı mesleklere benzettiğimiz olur. Öğrencilerinizi hiç mühendise benzettiğiniz oluyor mu? (Evetse) Ne gibi benzerlikler görüyorsunuz?
5. Mühendisliği sınıfınızda uyguladığınız eğitime dahil etmek ister miydiniz? Yoksa çocuklar mühendislikle ilgili bilgi ve becerileri üniversiteye geçtiğinde eğer mühendislik mesleğini seçerlerse o zaman mı öğrenmeli?
6. Sınıfınızda okul öncesi dönemde mühendislik ile ilgili bir eğitim verecek olsanız, bu eğitimin içeriğinde nelerin olmasını isterdiniz?
7. Okul öncesi dönem çocuklarının mühendislik eğitimi alması sizce önemli mi? Neden?
    a. Mühendislik eğitimi öğrencilerinize ne kazandırabilir?
8. Öğrencilerinizin mühendislik eğitimi sürecinde sizin de rolünüz olabileceğini düşünüyor musunuz?
    a. Evetse ne şekilde?
    b. Hayırsa neden?
9. Öğrencilerinizin mühendislik eğitimi sürecine destek olabilmek için neler yapabilirsiniz?
10. Diyelim ki okul öncesi eğitim müfredatımıza mühendisliğe yönelik kazanım ve göstergeler eklendi. Bu kazanım ve göstergelere yönelik etkinlikler hazırlamada ve uygulamak konusunda mühendislikle ilgili yeterli bilgi ve beceriye sahip olduğunuzu düşünüyor musunuz?
11. Mühendislik eğitimi aracılığıyla öğrencilerinizin başka alanlardaki (Fen, Teknoloji, Matematik, Türkçe, Sanat gibi) öğrenmeleri de desteklenebilir mi? Açıklar mısınız?
12. Diyelim ki müfredatımıza mühendislik eğitimine yönelik etkinlikler eklendi, sınıf ortamınızın çocukların mühendislik eğitimini destekleyici (malzeme, çalışma alanı vb. açısından) olduğunu düşünüyor musunuz? Açıklar mısınız?
13. Aile katılımını nasıl tanımlarsınız? Sizce hangi etkinlikler aile katılımı etkinlikleri sayılabilir?
14. Aile katılımına yönelik sınıfınızda ne gibi etkinlikler uygulamaktasınız?
    a. Bunların dışında, aile katılımına yönelik hangi yapmayı planladığınız etkinlikler var mı?

Appendix G: Child Post-Interview Questions

Çocuk Son-Görüşme Soruları

Seninle ve annenle/babanla beş defa etkinlik yaptık. Bu etkinliklerde;

1. Annen ve/veya babanla birlikte ne/neler tasarladınız? (Cevap alındıktan sonra, çocukla birlikte mühendislik defteri incelenir ve hem süreç hem de süreçte yapılanlar hatırlanır).

2. Annen ve/veya babanla yaptığınız tasarımlar bitti mi, yoksa üzerinde daha çalışmanız gerekiyor mu?

3. Birlikte şimdiye kadar neler yaptığınıza (mühendislik defterine) baktık. Peki daha zamanımız olsaydı bunlardan başka neler tasarlamak isterdin?

4. Anne ve/veya babanla tasarımlar yaparken anlaşamadığınızı düşündüğün zamanlar oldu mu?

a. Yapmakta anlaşamadığınız şey neydi?

b. Yapmakta en iyi anlaştığınız şey neydi?

5. Bütün arkadaşların ve onların anne/babaları kendi tasarımlarını bize sundular. Sen de onların çalışmalarını gördün. Peki diğer çocuklardan veya onların anne-babalarından öğrendiğin bir fikir oldu mu?

6. Bu dosyanın hepsine baktığımızda neler yaptığını gösteriyor. Bunların arasında en çok hangisi hoşuna gitti?

7. Bunları yaparken seni üzen bir şey oldu mu?

8. Büyüdüğünde hangi mesleği yapmak istiyorsun? Peki neden … olmak istiyorsun?

Benim sana sormak istediklerim bu kadar, senin başka söylemek istediğin bir şey var mı? Sorularımı cevapladığın için teşekkür ederim.

Appendix H: Parent Post-Interview Questions

Ebeveyn Son-Görüşme Soruları

Çocuklarınız ve siz değerli velilerimizle gerçekleştirdiğimiz mühendislik tasarım atölyelerimizin sonuna geldik. Size süreci gözden geçirmemizi sağlayacak birkaç soru sormak istiyorum. Sorulara vereceğiniz yanıtlar tamamen gizli kalacak ve size ya da çocuğunuza ait kişisel bilgiler hiç kimse ile paylaşılmayacaktır. Sizden birazdan soracağım soruları 5 haftalık mühendislik tasarım atölyelerimizde edindiğiniz deneyimleri göz önünde bulundurarak cevaplamanızı rica etmekteyim.

1. Mühendisliği nasıl tanımlarsınız? Mühendis ne iş yapar?

2. Sizce mühendislik insan yaşamını etkiler mi?
   a. Olumlu yönde etkileri olabilir mi? Örnek verebilir misiniz?
   b. Olumsuz yönde etkileri olabilir mi? Örnek verebilir misiniz?

3. Okul öncesi dönemde mühendislik eğitiminin önemli olduğunu düşünüyor musunuz? Mühendislik eğitimi çocuğunuza ne kazandırabilir?

4. Etkinliklerimizde deneyimlemiş olduğunuz mühendislik eğitiminin çocuğunuzun sınıfında uygulanan eğitime dahil olmasını ister miydiniz?

5. Çocuğunuzla mühendislik tasarım faaliyetlerini uygularken, sizce dikkate alınması gereken konular nelerdir?

6. Sizin ve çocuklarınızın katılımıyla atölye çalışmalarında uyguladığımız mühendislik tasarım etkinliklerinin daha etkili olabilmesi için önerileriniz nelerdir? Önerilerinizi gerekçeleri ile birlikte açıklar mısınız?

7. Sizce çocuğunuz ve onun öğretmeniyle mühendislik tasarım etkinliklerini uygulamak için bir araya geldiğiniz bu atölyede eğitim sürecini engelleyen faktörler var mıydı? Açıklar mısınız?

8. Sizce çocuğunuz ve onun öğretmeniyle mühendislik tasarım etkinliklerini uygulamak için bir araya geldiğiniz bu atölyede eğitim sürecini zenginleştiren/destekleyen faktörler var mıydı? Açıklar mısınız?

9. Atölye çalışması sırasında yaşanan mühendislik tasarım sürecinin, çocukların mühendislik veya diğer alanlardaki (Fen, Teknoloji, Matematik, Türkçe, Sanat gibi) öğrenmesini etkilediğini düşünüyor musunuz?
   - Evetse. Örnek vererek açıklar mısınız?
   - Hayırsa. Size bunu düşündüren nedir?

10. Bu atölye başladıktan itibaren çocuğunuzun okul ortamı dışındaki ilgi ve uğraşlarında, sorularında, sizin sorularınıza verdiği cevaplarda herhangi bir değişiklik gözlemlediniz mi? Açıklar mısınız?

11.Şimdiye kadarki atölye deneyiminize dayanarak, velisi olarak çocuğunuzun ev ve okul ortamında mühendisliğe yönelik öğrenmelerini destekleyebileceğinizi düşünüyor musunuz? Açıklar mısınız?

12. Sizin için bu etkinlikler sırasında çocuğunuzla birlikte başarıya ulaştığınızın göstergesi ne olabilir?

13. Sizce eğitimde aile katılımı nedir?

- Neler eğitimde aile katılımı olarak düşünülebilir?

21. Birlikte tecrübe ettiğimiz bu mühendislik tasarım atölyesini bir aile katılımı etkinliği olarak değerlendirmenizi istesem neler söylersiniz?

a. Çocuğunuzun mühendislik eğitimi ile ilgili böyle bir eğitim ortamına davet edilmek size nasıl hissettirdi?
b. Sizin de bu atölye sürecinde öğrendiğiniz yeni şeyler oldu mu?

a. Bu süreç sizi çocuğunuzun eğitimine katılmak için
   i. Bilgi
   ii. Beceri
   iii. Zaman
   iv. Enerji
   v. İstek bakımından etkiledi mi?

22. Bu atölyeye katıldıktan sonra, ev ortamınızda çocuğunuzun mühendislik eğitimini destekleyecek değişiklikler yaptınız mı? Açıklar mısınız?

Benim soracaklarım bu kadar sizin sormak veya eklemek istediğiniz bir şey var mı? Sabrınız ve katılımınız için teşekkür ederim.

Appendix I: Teacher Post-Interview Questions

Öğretmen Son-Görüşme Soruları

Saygıdeğer öğretmenim, öğrencileriniz ve velilerinizle gerçekleştirdiğimiz mühendislik tasarım atölyelerimizin sonuna geldik. Size süreci gözden geçirmemizi sağlayacak birkaç soru sormak istiyorum. Sorulara vereceğiniz yanıtlar tamamen gizli kalacak ve size, öğrencilerinize ya da velilerinize ait kişisel bilgiler hiç kimse ile paylaşılmayacaktır. Sizden birazdan soracağım soruları 5 haftalık mühendislik tasarım atölyelerimizde edindiğiniz deneyimleri göz önünde bulundurarak cevaplamanızı rica etmekteyim.

1. Kaç yaşındasınız?

2. Eğitim durumunuz (en son mezun olduğunuz okul) nedir?

3. Kaç yıldır öğretmenlik yapmaktasınız?

4. Bu dönem eğitim vermekte olduğunuz sınıftaki çocuk sayısı nedir?

5. Daha önce herhangi bir hizmet içi eğitime veya eğitimle ilgili böyle bir etkinliğe katıldınız mı?

6. Okul öncesi çocuklarını ve ebeveynlerini ilgilendiren mühendislik tasarım faaliyetlerinin hazırlanma aşamasında;
   - Göz önüne alınması gereken konular sizce nelerdir?
   - Araştırmacılara neler önerirsiniz? Önerilerinizi gerekçeleriyle birlikte açıklar mısınız?

7. Okul öncesi çocukları ve onların ebeveynlerine yönelik mühendislik tasarım müfredatının uygulanma aşamasında
   - Dikkate alınması gereken konular sizce nelerdir?
   - Karşılaştığınız zorluklar nelerdi?

8. Sizce öğrencileriniz ve onların ebeveynleriyle mühendislik tasarım etkinliklerini uygulamak için bir araya geldiğiniz bu atölyede eğitim sürecini engelleyen faktörler var mıydı? (Örneğin; öğrenme ortamının kalabalık oluşu veya velilerin öğrenme sürecine dahil oluşu gibi sebeplerden kaynaklanan olumsuzluklar). Açıklar mısınız?

9. Sizce öğrencileriniz ve onların ebeveynleriyle mühendislik tasarım etkinliklerini uygulamak için bir araya geldiğiniz bu atölyede eğitim sürecini destekleyen/zenginleştiren faktörler var mıydı? Açıklar mısınız?

10. Ebeveynlerin, çocukların ve öğretmenin mühendislik tasarım müfredatını uygulamak için bir araya geldiği böyle bir öğrenme ortamının avantajlarını/faydalarını açıklar mısınız?
   - Çocuk açısından
   - Veli açısından
   - Okul açısından

11. Atölyede uygulanan ebeveyn katılımına dayanan mühendislik tasarım etkinliklerinin öğrenme hedefleri sizce yeterince açık ve anlaşılır mıydı?

12. Atölyede uygulanan ebeveyn katılımına dayanan mühendislik tasarım etkinlikleri sizce çocukların sınıfınızdaki öğrenme deneyimleriyle uyumlu muydu?

13. Atölyede uygulanan ebeveyn katılımına dayanan mühendislik tasarım etkinlikleri sizce çocukların ilgi ve ihtiyaçlarına uygun muydu?

14. Atölyede uygulanan ebeveyn katılımına dayanan mühendislik tasarım etkinlikleri sizce farklı sınıflara ve bu sınıflarda bulunan veli ve çocukların ilgi ve ihtiyaçlarına uyarlanabilir mi?

15. Atölyede uygulanan ebeveyn katılımına dayanan mühendislik tasarım etkinlikleri sizce mevcut okul öncesi müfredatımızla uyumlu muydu?

16. Atölyede uygulanan ebeveyn katılımına dayanan mühendislik tasarım etkinlikleri sizce öğrenme hedeflerinin dağılımı açısından dengeli miydi?

17. Atölyede uygulanan ebeveyn katılımına dayanan mühendislik tasarım etkinlikleri sizce çocuklara keşfetme yoluyla öğrenme olanağı sağladı mı?

18. Atölyede uygulanan ebeveyn katılımına dayanan mühendislik tasarım etkinlikleri sizce çocuklara tasarım yoluyla öğrenme olanağı sağladı mı?

19. Atölyede uygulanan ebeveyn katılımına dayanan mühendislik tasarım etkinlikleri sizce çocukların yaratıcılıklarını ortaya koyma ve açık uçlu materyallerle deneyimler kazanma olanağı sağladı mu?

20. Atölyede uygulanan ebeveyn katılımına dayanan mühendislik tasarım etkinlikleri sizce ebeveynlerin çocuklarının öğrenmelerini desteklemesine olanak sağladı mı?

21. Atölyede uygulanan ebeveyn katılımına dayanan mühendislik tasarım etkinlikleri sizce size çocukları çok yönlü değerlendirme olanağı sağladı mı?

22. Atölye çalışmaları sırasında deneyimlenen mühendislik tasarım müfredatının, öğrencilerinizin mühendislik veya diğer disiplinlerdeki (Fen, Teknoloji, Matematik, Türkçe, Sanat gibi) öğrenmesine katkı sağladığını düşünüyorsunuz? Açıklar mısınız?

23. Atölye çalışmaları sırasında uygulanan mühendislik tasarım müfredatını bir aile katılımı etkinliği olarak değerlendirmenizi istesem neler söylersiniz?

a. Ebeveynlerin de dahil olduğu böyle bir eğitim ortamında öğretmenlik yapmak size nasıl hissettirdi?
b. Sizin de bu atölye sürecinde aile katılımına yönelik öğrendiğiniz yeni şeyler oldu mu?
c. Bu süreç sizi sınıfınızdaki çocukların ailelerini çeşitli etkinlikler aracılığıyla çocuklarının eğitimine dahil emek için

i. Bilgi
ii. Beceri
iii. Zaman
iv. Enerji
v. İstek bakımından etkiledi mi?

24. Şimdiye kadarki atölye deneyiminizden okul öncesi dönemde mühendislik eğitimi hakkında öğrendiklerinizi birkaç cümle ile özetler misiniz?

25. Mühendislik tasarım müfredatının uygulandığı bu beş haftalık atölye süreci boyunca zorlandığınız noktalar oldu mu? Evetse, nasıl üstesinden geldiniz?

26. Bu atölyenin mesleki gelişiminizi olumlu ya da olumsuz yönde etkilediğini düşünüyor musunuz?

27. Bu atölyenin öğretmenlik mesleğine yönelik motivasyonunuzu olumlu ya da olumsuz yönde etkilediğini düşünüyor musunuz?

28. Bu atölye bilime yönelik düşüncelerinizi olumlu ya da olumsuz yönde etkiledi mi?

29. Mühendislik tasarım sürecine yönelik bu tür uygulamaları kendi sınıf içi etkinliklerinize dahil etmeyi düşünüyor musunuz? Neden?

Benim soracaklarım bu kadar sizin sormak veya eklemek istediğiniz bir şey var mı? Sabrınız ve katılımınız için teşekkür ederim.

Appendix J: Parent and Teacher Journal Questions

Ebeveyn ve Öğretmen Günlüklerinde Yer Alan Sorular

Saygıdeğer Velim

Bugünkü etkinliğe yönelik gözlem ve deneyimleriniz doğrultusunda aşağıdaki soruları birkaç cümle ile cevaplamanızı rica ediyorum.

Bugün çocuğunuzda öğrenme adına ne gibi değişiklikler gözlemlediniz?

Bugünkü etkinlik deneyiminizi aşağıdaki boşluğa birkaç cümle ile özetleyiniz.

Sayın Öğretmenim

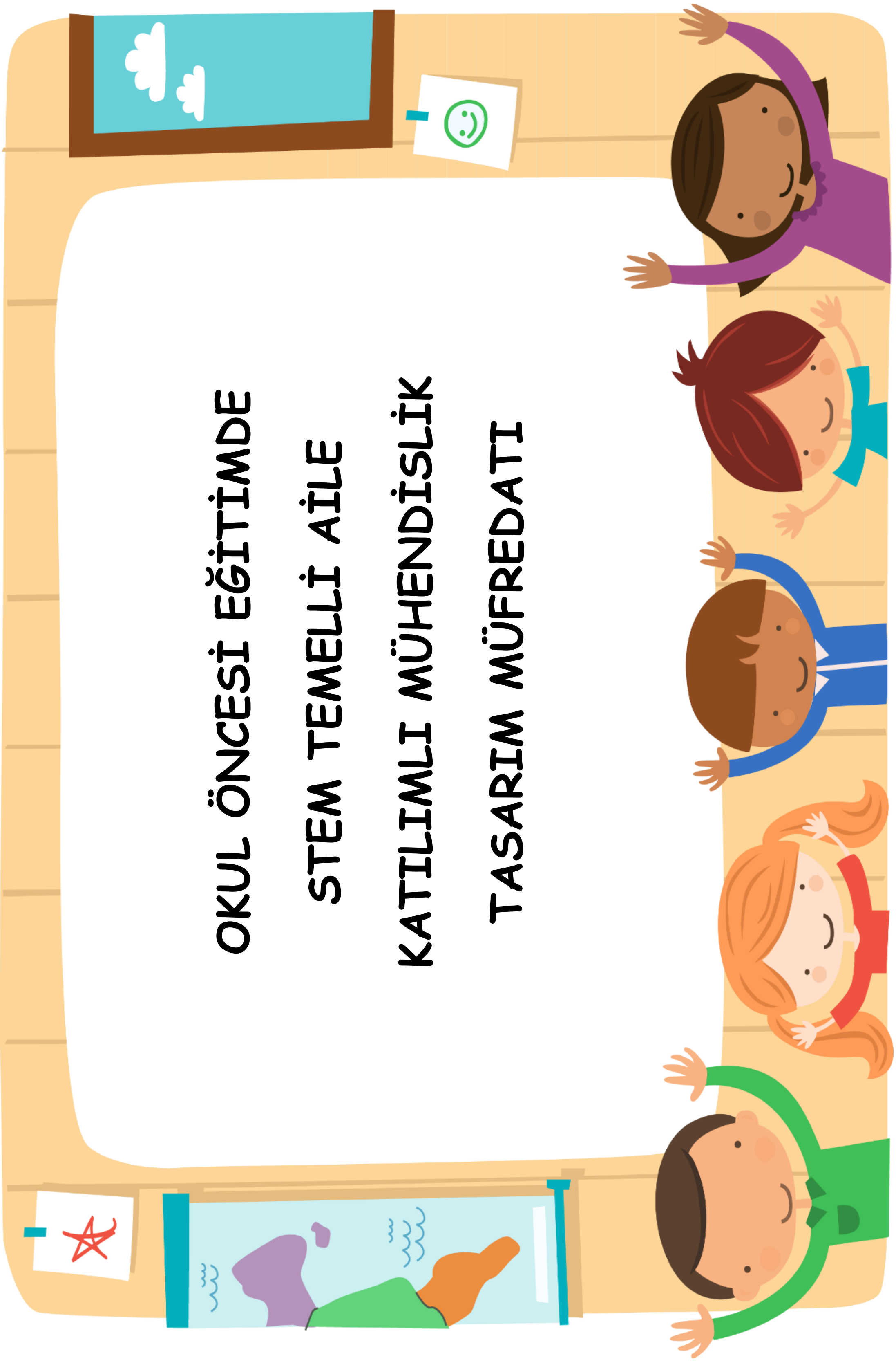
Bugünkü etkinliğe yönelik gözlem ve deneyimleriniz doğrultusunda aşağıdaki başlıklara birkaç cümleden oluşan açıklamalar yapmanızı rica ediyorum.

Bugün öğrencilerinizde öğrenme adına ne gibi değişiklikler gözlemlediniz?

Bugünkü etkinlik sırasında sizin de yeni öğrendiğiniz/keşfettiğiniz bir şey oldu mu?

Bugünkü etkinlik deneyiminizi aşağıdaki boşluğa birkaç cümle ile özetleyiniz.

Appendix K: A STEM-Based Engineering Design Curriculum for Parental Involvement in Early Childhood Education (EDCPI)



OKUL ÖNCESİ DÖNEM ÇOCUKLARI İÇİN STEM TEMELLİ AİLE KATILIMLI MÜHENDİSLİK TASARIM MÜFREDATI

"*Okul Öncesi Dönem Çocukları için STEM Temelli Aile Katılımlı Mühendislik Tasarım Müfredatı*" okul öncesi dönem çocuklarının özgün ve yaratıcı düşüncelerinden ve günlük problemleri çözme yöntemlerinden ilham alınarak geliştirilen ve 60-72 aylık çocuklara, bu çocukların ebeveynlerine ve okul öncesi öğretmenlere hitap eden bir müfredattır. Müfredat ilgili alan yazın ve alan uzmanlarının fikir ve önerileri rehber alınarak hitap ettiği yaş grubunun özelliklerine uygun şekilde tasarlanmıştır. Tasarlanan müfredat 2017-2018 bahar ve 2018-2019 güz dönemlerinde olmak üzere, gerçek sınıf ortamında ve hedef kullanıcılarından iki farklı örneklem ile test edilmiş ve katılımcı okul öncesi öğretmenleri ile iş birliği yapılarak geliştirilmiştir.

Okul öncesi dönem çocuklarına ebeveynlerinin rehberliğinde STEM (Fen, Teknoloji, Mühendislik, Matematik) alanlarında çeşitli öğrenme deneyimleri sağlamayı hedefleyen müfredat STEM disiplinlerinden çeşitli bilgi ve becerileri tek bir faaliyette yoğurmayı mümkün kılan mühendislik alanına odaklanmaktadır. Mühendislik kısaca bilim, teknoloji, matematik ve yaratıcılıktan yararlanarak günlük yaşam problemlerinin sistematik bir şekilde çözülmesi olarak tanımlanabilir. Mühendislik ve teknolojinin hayatımızda yadsınamaz bir öneme sahip olduğu günümüz dünyasında, bir disiplin ve muhtemel bir kariyer alanı olarak mühendisliğin ne olduğunu, mühendislerin ne iş yaptığını ve ürettikleri teknolojilerin kullanım alanlarını bilmek gelecek nesillerin hem bu alanda ilerlemeleri açısından hem de günlük yaşam problemlerinin çözümünde mühendisliği bir beceri olarak edinmeleri açısından oldukça önemlidir. Tüm bunların yanı sıra, gelişimsel olarak uygun bir mühendislik eğitimi aracılığıyla okul öncesi dönem çocuklarının çeşitli bilimsel ve matematiksel kavram ve becerileri somut ve eğlenceli bir biçimde deneyimlemelerini sağlamak mümkündür. Tüm bunların yanı sıra, mühendislik eğitimi çocuğun mühendislik tasarım sürecinin adımlarını deneyimlemesini, çocuğun merak ve yaratıcılığına hitap ederek belli bir problemi çözebilecek nitelikte teknolojiler üretmesini, ebeveyni ve/veya yaşıtları ile işbirlikli olarak çalışabilmesini ve bu sırada bilişsel, motor ve sosyal-duygusal gelişim olmak üzere pek çok gelişim alanında kazanımlar edinmesini sağlayabilir.

Okul öncesi dönem çocuklarının yakın çevrelerinde en sık ve düzenli olarak bulunan kişiler olarak ebeveynler, çocuklarına sağladıkları öğrenme fırsatları aracılığıyla onların mühendislik ve STEM'in diğer alanlarındaki öğrenmeleri için oldukça önemli bir role sahiptir. Dolayısıyla ebeveynlerin çocuklarının bu alanlardaki öğrenmelerini ev ve okul ortamında ne şekilde destekleyebilecekleri konusunda bilgi sahibi olması oldukça önemlidir. Ebeveynlerin çocuklarının STEM eğitimine sağlayabileceği potansiyel katkılardan yola çıkılarak hazırlanan bu müfredat ebeveynleri ev ve okul ortamında çocuklarının mühendislik eğitimine dahil etmeyi ve eğitim sürecinin temel paydaşlarından olan öğretmenler, ebeveynler ve çocuklar için birlikte öğrenmeyi mümkün kılmayı hedeflemektedir.

Okul Öncesi Dönem Çocukları için STEM Temelli Aile Katılımlı Mühendislik Tasarım Müfredatının Temel Amaçları

Müfredatın temel amaçları;

1. Okul öncesi çocukların mühendislik etkinlikleriyle meşgul olmalarını, tasarım problemlerini tanımlamaları, dünyadaki tasarım olanaklarını ayırt edebilmeleri ve malzemelerin nasıl yeniden tasarlanabileceği ve STEM alanlarında bilgi ve beceriler gerektiren tasarım problemlerini nasıl çözebilecekleri hakkında düşünmeleri için yeni fırsatlar yaratmak,
2. Ebeveynlerin, uygulamalı etkinlikler yoluyla çocuklarının mühendislik eğitimine dahil edilmesi ve böylece okul ile aile arasında ortak hedefi çocuğun gelişimi ve eğitimi olan bir köprü kurmak,
3. Mühendislik eğitimini sınıflarına entegre etmek ve etkili bir aile katılımı etkinliği uygulamak isteyen okul öncesi öğretmenlerini desteklemek için gelişimsel olarak uygun bir kaynak sağlamaktır.

Okul Öncesi Dönem Çocukları için STEM Temelli Aile Katılımlı Mühendislik Tasarım Müfredatının Temel Özellikleri

Müfredatın araştırma tabanlı ve sınıf ortamında test edilmiş sekiz temel özelliğinden söz etmek mümkündür.

1. Gelişimsel olarak uygundur:

- *Öğrenme hedefleri açıkça tanımlanmış ve ifade edilmiştir*: Öğrenme hedefleri (kazanım ve göstergeler) ilgili alan yazın doğrultusunda belirlenmiş, açıkça tanımlanmıştır ve ilgili aktivite şablonunda öğretmenlere rehber olması açısından açıkça sunulmuştur.
- *Sınıf deneyimleri ve günlük yaşamla tutarlıdır*: Müfredat çocukların aşina olduğu ve hem okul yaşamlarıyla hem de okul dışındaki günlük yaşamlarıyla ilişkili öğrenme deneyimlerini içermektedir. Müfredat kapsamındaki etkinlikler, çocuklara mühendislik bilgisi ve görevlerinin nasıl ve nerede uygulanabileceğini gösteren gerçek yaşam durumlarıyla bağlantılı olarak düzenlenmiştir.
- *Gelişimsel ilgi, ihtiyaç ve özelliklere uygundur*: Müfredatta yer alan tüm faaliyetler ve ilgili öğrenme hedefleri, çalışılan yaş grubunun gelişimsel özellikleri ve ihtiyaçları ile kültürel ve aile bağlamları hakkında bilinenler ışığında belirlenmiştir. Bu noktada, müfredat kapsamındaki tüm müfredat materyalleri ve etkinlikleri, ilgili alan yazının rehberliğinde ve 60-72 aylık çocukların özelliklerini, ihtiyaçlarını, öğrenme yollarını ve aile ortamlarını bilen kaynaklardan biri olduğu için okul öncesi öğretmenleri ile iş birliği yapılarak hazırlanmıştır.

- *Mevcut erken çocukluk eğitimi (ECE) müfredatı ile bağlantılıdır:* Bu müfredat kapsamındaki öğrenme aktiviteleri mühendislik ve STEM ile ilgili öğrenme hedeflerine ek olarak, mevcut ECE müfredatında özellikle bilişsel, psikomotor ve sosyal-duygusal gelişim açısından hedeflenen bazı kazanım ve göstergelere de hitap edecek şekilde hazırlanmıştır. Müfredatı aynı zamanda mevcut ECE müfredatında yer alan pek çok kavram ile paralel şekilde hazırlanmıştır (e.g. uzun-kısa, ıslak-kuru, geniş-dar, büyük-küçük, önce-şimdi-sonra, kirli-temiz, ıslak-kuru, sert-yumuşak, içinde-dışında, yukarı-aşağı vb.) (Millî Eğitim Bakanlığı, 2013).

2. **Öğrenme hedefleri dengeli şekilde dağılmıştır:** Müfredatta yer alan öğrenme hedefleri, okul öncesi dönemde öğrenmenin dört temel boyutuna (bilgi, beceriler, eğilimler ve duygular) (Katz, 1999) ve çeşitli gelişim alanlarına (örneğin, sosyal, bilişsel, fiziksel) dengelenmiştir. Bu denge, bu müfredatta ele alınan beş farklı düşünce becerisi için de geçerlidir. Her ne kadar etkinliklerin çoğu, çocukları birden fazla düşünme biçiminde desteklemek için kullanılabilir olsa da müfredat, her biri bir düşünme becerisine odaklanan beş örnek etkinlik içermektedir.

3. **Keşfederek öğrenme:** Müfredat okul öncesi çocukları, öğrenme sürecine aktif şekilde katılmaya ve hem açık uçlu günlük materyallerle (ör. Lastik bant, plastik şişe, alüminyum folyo, kâğıt havlu, karton, kumaş, plastik kap, düğme, kasnak, mermer) hem de doğal materyallerle (örneğin yaprak, çam kozalağı, ağaç dalları, taşlar) keşfederek öğrenmeye teşvik etmektedir. Bu şekilde çocuklar, bu malzemelerin yüzey, boyut ve yapımlarında kullanılan malzemeler gibi farklı özelliklerini keşfetme fırsatını bulabilir. Ayrıca, müfredat çocukları soru sormaya ve mühendislik tasarım süreci yoluyla olası cevapları keşfetmeye teşvik ederek araştırma yoluyla öğrenmeyi desteklemektedir.

4. **Tasarım yoluyla öğrenme:** Bu müfredatta deneyimlenen mühendislik tasarım süreci, okul öncesi çocukların bir sorunu tanımalarını, olası çözümler hakkında düşünmelerini, çözümleri hakkında bir plan yapmalarını ve ebeveynlerinin rehberliğinde mühendislik tasarım sürecini deneyimleyerek çözümlerini test etmelerini ve geliştirmelerini sağlamaktadır. Bu bağlamda, her bir aktivitede çocuklara açık-uçlu (tek bir cevaptan ziyade pek çok çözüm ve cevaba izin veren) ve çocuğun yaratıcılığını güçlendiren tasarım problemleri sunulmaktadır.

5. **Okul öncesi dönem çocuklarına STEM deneyimi sağlar:** STEM yaklaşımı üzerine temellendirilen bu müfredat çocuklara, STEM kavramları ile ilgili bilgi ve becerilerini mühendislik tasarım etkinlikleri aracılığıyla kullanma ve geliştirme fırsatını sağlamaktadır. Çocuklar müfredat içindeki mühendislik tasarım faaliyetlerinde yer alarak yalnızca mühendisliği değil aynı zamanda matematik ve fen bilimleri ilgili kavramları da deneyimlemektedir. Çeşitli tasarım problemlerine çözümler tasarlayan çocuklar aynı zamanda kendi teknolojilerini üretmektedirler.

6. **Yaratıcılık ve günlük yaşam materyallerinin kullanımına dayalı deneyimlere önem verir:** Müfredatta tüm öğrenme süreci çocukların yaratıcı potansiyelleri üzerine kurulmuştur. Müfredattaki tüm etkinlikler, çocukların kendilerini ve yaratıcılıklarını benzersiz bir şekilde ifade etmelerini sağlayacak şekilde tasarlanmıştır. Ayrıca, müfredatta yer alan tüm faaliyetler çocukların açık uçlu günlük yaşam materyallerini farklı şekillerde kullanmalarına izin veren faaliyetledir. Açık-uçlu materyaller tek başlarına ya da başka materyallerle kullanılabilen, taşınabilir, birleştirilebilir, yeniden tasarlanabilir, geri dönüştürülebilir, sıraya sokulabilir, parçalara ayrılabilir ve çeşitli şekillerde bir araya getirilebilir materyallerdir. Bu materyaller doğal (taşlar, ağaç dalları, kozalak, su, yapraklar, çakıl taşları, kum vb.), imal edilmiş (ahşap bloklar, karton, arındırılmış süt şişeleri, plastik kaplar, plastik borular, plastik ve tahta kaşıklar, kumaş, tuğla, vb.) ve/veya mevsime veya bulunulan bölgeye bağlı olarak temin edilebilecek materyaller (deniz kabukları, deniz yosunu, palmiye yaprakları vb.) olabilir (Neill, 2013).

7. **Öğrenme süreci ebeveyn iskelesi ile desteklenmektedir:** Müfredatın uygulanma süreci ebeveynlerin iskele yönteminde yer alan bazı stratejilerden yararlanmalıdır. Buna göre, ebeveynler çocukların problem çözme macerasına eşlik etmeli ve doğru cevapları vermek yerine çocukların doğru cevapları bulmalarına izin vermeli, başarının mutlaka bir ürün ortaya çıkarmak olmadığını hatırlamalı ve başarılı bir performansın nasıl görüneceği konusunda çocuklarıyla ortak bir anlayışa sahip olmalıdırlar. Ebeveyn çocuğun ne söylediğiyle ve ne yaptığıyla ilgilenmeli, çocuğun çalışmaları hakkında olumlu yorumlarda bulunmalı, ek destek için çocuğun ihtiyaçlarını yakından takip etmeli, çocukları ile duyarlı ve zevkli bir iş birliği kurmaya odaklanmalı, çocuğu başarılı olduğunda sözlü olarak övmeli, çocuğu başka bir çocukla veya çocuğun tasarımını başka bir çocuğun tasarımıyla karşılaştıramamalı, görevi çocuk tarafından başarılabilecek aşamalara bölerek ve çocuğun gerçekten yardıma ihtiyaç duyduğu durumlarda müdahale ederek sürece katkı sağlamalıdır.

8. **Değerlendirme çok yönlüdür:** Değerlendirmede hem öğrenme süreci hem de ortaya çıkarılan ürün önemlidir. Başarılı bir tasarımda, ürün çocuğun fikirlerini ve çabalarını yansıtmalıdır. Müfredatta ayrıca her çocuğun çok yönlü ve bireysel değerlendirmesine önem vermelidir. Bu değerlendirme, başlangıç noktası ile belirli bir zamanda ulaşılan nokta arasındaki farka bakılarak yapılmalıdır ve çocuğun öğrenme sürecini yansıtan portfolyolar ve müfredatta yer alan çocuk gözlem formları ile yapılmalıdır. Her bir ebeveyn-çocuk grubu için ayrı bir portfolyo dosyası oluşturulmalıdır. Bu dosyada ebeveyn ve çocuğun mühendislik tasarım sürecindeki deneyimlerini ve süreçte ortaya çıkardıkları plan, model ve tasarımı yansıtan fotoğrafların yer aldığı mühendislik defterleri yer almalıdır. Gözlem formları ise öğretmen tarafından öğrenme süreci dikkatli şekilde gözlemlenerek doldurulmalıdır.

Okul Öncesi Dönem Çocukları için STEM Temelli Aile Katılımlı Mühendislik Tasarım Müfredatında Ebeveynin Rolü

Ebeveynler, çocuğun merkezde olduğu bu öğrenme sürecinin rehberleridir. Bu nedenle, ebeveynlere, kendi başlarına bir fikir veya çözüm ürettikleri ve inşa ettikleri ve çocuğun ise öğrenme sürecinde aktif bir katılımcı olamadığı bir tasarım sürecinin başarılı olamayacağı bildirilmelidir. Ebeveynlere ayrıca, bu süreçte çocuğun başarısının, sadece ürettiği ürünle değil, süreçte öğrendikleriyle de ilgili olduğu bilgisi verilmelidir. Öyle ki, başarısızlıkla sonuçlanan denemeler yeni öğrenmelere yol açan fırsatlar olarak görülmelidir. Bu süreçte ebeveynler iskele yöntemi çerçevesinde, aşağıdaki gibi belirlenen şekillerde öğrenme sürecine rehberlik edebilir;

- Öğrenme sürecinde çocuğa sorgulama ve düşünme gibi becerilerde model olmak.
- Başarısızlık durumunda, çocuğu hatanın veya eksikliğin nerede olduğunu düşünmeye ve tekrar tekrar denemeye teşvik etmek.
- Öğrenme sürecine çocuğun ancak bir yetişkinin yardımı olmadan baş edemediği durumlarda müdahale etmek. Örneğin, bir çocuk daha önce hiç ölçüm yapmamışsa ölçme aracını (örneğin bir cetvel veya mezura) nasıl kullanacağını bilemeyebilir ve / veya ölçüm aletinde yer alan sayıları tanımakta zorluk çekebilir. Böyle bir durumda, çocuğun ölçme becerisini kazanmak için bir yetişkinin rehberliğine ihtiyacı vardır.
- Çocuk bir beceride uzmanlık kazandıkça desteği yavaş yavaş azaltmak. Ancak bu, ebeveynin çocuğa ilk hafta etkinliklerinde çocuğa rehberlik edip sonraki haftalarda pasif kalacağı anlamına gelmez. Ebeveynin rolü çocuğunu gözlemlemek ve çocuğa gerçekten ihtiyaç duyduğu sırada gerekli desteği sağlayabilmektir. Bu destek bazen çocuğu düşünmeye teşvik etmek, bazen çocuktan gelen yardım çağrısına cevap vermek ve bazen çocuğun aktivite sırasında öğrendiklerini günlük yaşamla ilişkilendirmesine yardımcı olmak için bir örnek vermek veya soru sormak şeklinde olabilir.
- Çocuğun fikir ve sorularına duyarlı olmak ve çocuğun çözüm üzerinde aktif olarak düşünmesini, keşfetmesini, tasarlamasını ve test etmesini teşvik etmek (MacNaughton ve Williams, 2008; Stone-MacDonald ve diğ., 2015).
- Çocuğun mühendislik eğitimini, müfredat kapsamında yer alan ev temelli aile katılımı etkinlikleri aracılığıyla ve okul dışındaki ortamlarda meydana gelen öğrenmeleri pekiştirerek ev ortamında da sürdürmek
- Çocuğun öğrenme sürecine rehberlik etmek için gerekli yöntem ve stratejilerin yanı sıra, okul öncesi dönem mühendislik eğitimi alanında kendileri için yeni olan bilgi ve becerileri öğrenmeye açık ve istekli olmak.

Okul Öncesi Dönem Çocukları için STEM Temelli Aile Katılımlı Mühendislik Tasarım Müfredatında Öğretmenin Rolü

Okul öncesi dönem çocukları, onların ebeveynleri ve öğretmenleri için hem mühendislik ve STEM eğitimini okul öncesi eğitim ortamlarına entegrasyonunun hem de okul öncesi eğitimde aile katılımının alternatif bir yolunu sunmayı hedefleyen bu müfredatta öğretmenin rolü de tıpkı ebeveynler gibi sürece rehberlik etmektir. Fakat ebeveynden farklı olarak öğretmen süreçte hem çocuğun hem de ebeveynin rehberi olacaktır. Bu nedenle, öğretmen tüm ebeveynlere süreçte ne gibi bir rolleri olduğu ve sürece nasıl rehberlik edebileceklerini açıklamalıdır. Müfredat içeriği aileler arasında sosyal ve kültürel birtakım farklılıklar olabileceği göz önünde bulundurularak hazırlanmıştır. Öğretmenin de uygulama sürecinin herhangi bir kültürel, etnik veya sosyal önyargı içermemesine özellikle dikkat etmesi gerekmektedir. Ebeveynler ve okul arasında çocuğun eğitimi ve gelişimi hedef alınarak yapılan bu iş birliğinde, öğretmen ebeveynlerin okul ortamında kabul gördüğünü çocuklara ve ebeveynlere hissettirmelidir. Müfredatta öğretmen tarafından üstlenilmesi beklenen bir diğer rol ise mühendislik tasarım sürecinde çocuğu merak etmeye, düşünmeye, sorgulamaya, üretmeye ve denemeye teşvik etmektir. Öğretmen bunu aktivite şablonlarında yer alan sorular aracılığıyla ve bu soruları çeşitlendirerek yapabilir. Bu süreçte, fikirlerinin önemsendiğini, başarısının ve yaratıcılığının takdir gördüğünü, başarısızlıkların kabul edildiğini, pek çok kez iyileştirme ve yeniden deneme şansının olduğunu, ailesinin de kendisi gibi eğitim ortamında değer gördüğünü deneyimlemek çocuk için oldukça önemlidir. Öğretmen içerikte yer alan aktiviteleri kendi sınıfındaki çocukların özelliklerine, bulunduğu bölgenin imkanlarına ve kendi sınıfında uyguladığı müfredata adapte edebilir. Ayrıca müfredatta yer alan kazanım ve göstergeler rehberliğinde kendisi de aile katılımlı mühendislik tasarım etkinlikleri tasarlayıp uygulayabilir. Son olarak, öğretmen süreci portfolyolar ve gözlem formları aracılığıyla değerlendirmelidir ve bu da detaylı bir gözlem gerektirmektedir. Bu süreçte, öğretmen de tıpkı ebeveyn gibi üründen ziyade sürece, çocuğun çabalarına, çocuğun gelişim ve öğrenme bakımından kat ettiği mesafeye ve her ebeveyn-çocuk grubunu bireysel olarak değerlendirmeye odaklanmalıdır.

Okul Öncesi Dönem Çocukları için STEM Temelli Aile Katılımlı Mühendislik Tasarım Müfredatında Değerlendirme

Bu müfredatta öğrenme dört başlıkta değerlendirilmektedir. İlk olarak bilgi boyutu beş kazanım ve bu kazanımlar kapsamında toplam on göstergeden oluşmaktadır. Her bir kazanımda yer alan göstergelerin en az yarısını gösteren çocuk bu kazanıma ulaşmış olarak kabul edilir. Bilgi boyutundaki öğrenmelere yönelik değerlendirme çocukların öğrenme sürecinde verdikleri örnekler ve yine etkinliklerin giriş kısımlarında sorulan sorulara verdikleri cevaplar aracılığıyla yapılmalıdır. Diğer üç boyut (beceriler, eğilimler, duygular) ise gözlem formu aracılığıyla değerlendirilmelidir Beceriler boyutunda yedi öğrenme hedefi altında toplanmış toplam 30 gösterge er almaktadır. Gözlemlenen her bir gösterge 1 puana karşılık gelmektedir. Bu boyuttan elde edilen puana göre çocuğun mühendislik becerileri bakımından gelişmekte (0-10 puan), yeterli (10-20 puan) veya (20-30 puan) gelişmiş olduğu yorumu yapılabilir. Eğilimler ve duygular boyutlarında ise göstergeler baz alınarak yapılacak açık-uçlu bir değerlendirme söz konusudur.

BİLGİ BOYUTUNDAKİ ÖĞRENME HEDEFLERİ

Kazanımlar	***Göstergeler***
K1: Mühendisliğin ne anlama geldiğini kavrar.	**K1.1** Mühendislerin ne iş yaptığını söyler.
	K1.2 Mühendislerin insanların yaşamını kolaylaştırmak ve ihtiyaçlarını karşılamak için çalıştıklarını ifade eder.
K2: Günlük yaşamda kullanılan mühendislik ürünlerini tanır.	**K2.1** Çevresinde gördüğü teknolojilere örnekler verir.
	K2.2 Doğal nesneleri insan yapımı nesnelerden ayırt eder.
K3: Mühendisliğin çeşitli alanlarını keşfeder.	**K3.1** Çeşitli alanlarda çalışan mühendisler tarafından üretilen teknolojilere örnekler verir.
	K3.2 Mühendisliğin insan dünyasının pek çok alanında nasıl etkili olduğuna yönelik açıklamalar yapar.
K4: Herkesin mühendis olabileceğini ve bir mühendis gibi düşünebileceğini kavrar.	**K4.1** Farklı cinsiyetlerden mühendislere ve bu mühendisler tarafından üretilen teknolojilere örnekler verir.
	K4.2 Kendisinin ve/veya çevresindeki herhangi birinin bir mühendis gibi düşünüp sorunlara çözümler ürettiği durumlara örnekler verir.
K5: Mühendislik ve teknolojinin dünyanın ve toplumun gelişimindeki rolünü kavrar.	**K5.1** Mühendislik ve teknolojinin gelişmediği dönemler ve günümüz şartlarını kıyaslar.
	K5.2 Mühendislik ve teknolojinin toplumu nasıl etkilediğine örnekler verir.

BECERİLER BOYUTUNDAKİ ÖĞRENME HEDEFLERİ

Kazanımlar	*Göstergeler*
S1: Gözlem ve araştırma yoluyla bir mühendislik ürünü geliştirerek çözülebilecek bir mühendislik problemini tanımlar.	**S1.1** Problemi veya ihtiyacı belirler. **S1.2** Problemle ilgili ön bilgilerini gözden geçirir. **S1.3** Problemle ilgili sorular sorar. **S1.4** Problemi çözmekteki amacı belirler. **S1.5** Problemi çözmek için kuralları (sınırlılıkları ve gereklilikleri) belirler. **S1.6** Mevcut materyalleri sınırlılıklar açısından keşfeder (örneğin; plastik dondurma kabının üzerine su sıkıp su geçirip geçirmediğini test eder).
S2: Probleme olası çözümler üretir ve ürettiği fikirleri basit bir plan ve/veya model yoluyla ifade eder.	**S2.1** Materyallerin nasıl kullanılabileceği ve dönüştürülebileceği hakkında beyin fırtınası yapar (örneğin; çubukları yan yana sıralayıp bantla birleştirerek köprü oluşturur). **S2.2** Problemi çözmek için materyallerin birlikte nasıl kullanılabileceği hakkında beyin fırtınası yapar (örneğin; büyük bir süngere çubuk batırıp suya daldırarak sudaki atıkları süzebileceğini düşünür). **S2.3** Problemi çözmek için fikir üretir. **S2.4** Fikirlerini plan çizerek temsil eder ve/veya çözümün nasıl görüneceği ve nasıl çalışacağını sözel olarak ifade eder. **S2.5** Model yapımında gerekli olan materyalleri belirler. **S2.6** İnşa ettiği modeli test eder. **S2.7** Model üzerinde yaptığı denemeden yola çıkarak tasarımı için yeni fikirler üretir.

BECERİLER BOYUTUNDA ÖĞRENME HEDEFLERİ

Kazanımlar	*Göstergeler*
S3: Bir tasarım inşa eder ve bu tasarımı geliştirmeye çalışır.	**S3.1** Problemi çözmek için tasarladığı planı takip eder. **S3.2** Problemin sınırlılık ve gerekliliklerini göz önüne alarak tasarımı için uygun materyali seçer. **S3.3** Materyaller üzerinde ebeveyni ile iş birliği halinde çalışır. **S3.4** Problemi çözmek için bir tasarım inşa eder veya bir önceki adımda inşa ettiği modeli geliştirir. **S3.5** Tasarımını test ettikten sonra problemi çözüm çözmediğine karar verir. **S3.6** Test etme aşamasında neler olduğunu ve bunun tasarımın bir sonraki versiyonu için ne anlama geldiğini açıklar. **S3.7** Tasarımını geliştirmeye yönelik fikirler üretip uygular. **S3.8** Çeşitli geliştirme çabalarından sonra tasarımını amaca ulaşana kadar tekrar tekrar test eder. **S3.9** Tasarımı problemin sınırlılık ve gerekliliklerine uygundur. **S3.10** Tasarım sürecini ve tasarımının son halini diğer gruplarla paylaşır. **S3.11** Başlangıç fikirlerini ve tasarımın son prototipini bu iki durum arasındaki farklara değinerek kıyaslar.
S4: Bir mühendislik probleminin birden çok çözümü olabileceğini kavrar.	**S4.1** Aynı mühendislik problemine diğer gruplar tarafından önerilen çözümleri keşfeder. **S4.2** Kendisine sunulan mühendislik problemi için tasarladığının dışında (tasarladığından farklı) olası çözüm fikirleri üretir.

BECERİLER BOYUTUNDA ÖĞRENME HEDEFLERİ

Kazanımlar	*Göstergeler*
S5. Materyal seçiminin mühendislikteki kilit rolünü kavrar.	**S5.1** Belli bir materyali tasarımında neden kullandığını açıklar.
S6: Matematikle ilgili bilgi ve becerilerini mühendislik tasarım problemlerine uygular.	**S6.1** Mühendislik tasarım sürecinde matematik bilgi ve becerilerinden yararlanır. ○ Sayılarla çalışma (nesneleri sayma, sayıları tanıma) ○ Nicelik bilgisi (bir dizide yer alan nesne sayısını bilme) ○ İlişki belirten ifadeler kullanma (nesnelerin sayıları/miktarları arasında daha fazla, daha az, eşit gibi ilişkiler kurabilme) ○ Basit toplama çıkarma **S6.2** Mühendislik tasarım sürecinde geometri, uzamsal düşünme ve ölçme gibi alanlardaki bilgi ve becerisinden yararlanır. ○ Mekânda konum ile ilgili ifadeler kullanma (altında, üstünde, yanında). ○ İki ve/veya üç boyutlu geometrik şekiller hakkında bilgi sahibi olma (“Anne bak, dikdörtgen bir çatı yapmak için iki üçgeni birleştirdim.”) ○ Geometrik şekilleri ayırarak ve birleştirerek yeni şekiller oluşturma. ○ Çevresinde gördüklerini zihninde canlandırma. ○ Çevresindeki nesnelerin büyüklük-küçüklük ve konum bakımından ilişkisine uygun modeller yaratma. ○ Nesneleri standart ve standart olmayan ölçme araçlarıyla ile ölçme.

BECERİLER BOYUTUNDA ÖĞRENME HEDEFLERİ

S7: Fen bilgisini mühendislik tasarım problemlerine uygular.	S7.1 Mühendislik tasarım sürecinde fen ile ilgili bilgisinden (canlı/cansız varlıklar, yaşam alanları, çevresel ihtiyaçlar ve bitki ve hayvanları spesifik özellikleri, doğada meydana gelen değişimler, doğal materyaller, bilimsel kavramlar).

EĞİLİMLER (DÜŞÜNME BECERİLERİ) BOYUTUNDA ÖĞRENME HEDEFLERİ

Düşünme becerisi	*Göstergeler*
Meraklı düşünme (D1)	**D1.1** Yeni şeyler öğrenme ve yeni deneyimler edinme konusunda isteklidir. **D1.2** Gözlemlenebilir durumları gözlemler ve gözlemleri hakkında sorular sorar. **D1.3** Giderek daha bağımsız seçimler yapar. **D1.4** Çok sayıda konu ve fikri öğrenmek için isteklidir. **D1.5** Bilgi almak için sorular sorar. **D1.6** Basit araç gereçleri kullanarak araştırmalar planlar ve uygular. **D1.7** Problemlere çözümler üretmenin yollarını araştırır ve keşfeder.
Israrcı düşünme (D2)	**D2.1** Başarılı olana dek birkaç kez dener. **D2.2** Problemi çözmek için bir plan tasarlayıp yürütür. **D2.3** Planlamayı ve amacının peşinden gitmeyi amacına ulaşana kadar sürdürür. **D2.4** Yönlendirme ve bölünmelere rağmen çalışmasına uzun süre dikkatini verebilir. **D2.5** Çözümü test eder ve test sonuçlarına göre çözümü üzerinde değişiklikler yapar.
Esnek düşünme (D3)	**D3.1** Bir problem için birden çok çözüm yolu önerir. **D3.2** Problem için önerdiği çözümü denemeden önce çeşitli yollarla (plan, taslak, model…) temsil eder. **D3.3** Bir problemi çözmek için girişimde bulunduğunda uyum yeteneği, hayal gücü ve icat kabiliyeti sergiler. **D3.4** Çevresindeki insanların problemleri nasıl çözdüklerini gözlemler ve onlardan ilham alır. **D3.5** Ebeveyninin ve/veya yaşıtlarının öneri ve fikirlerine açıktır. **D3.6** Kendini en az yardım ile yeni durumlara ve insanlara alıştırır.

EĞİLİMLER (DÜŞÜNME BECERİLERİ) BOYUTUNDA ÖĞRENME HEDEFLERİ

Düşünme becerisi	*Göstergeler*
Esnek düşünme (D3)	**D3.7** Problemi tüm olasılıkları denemek zorunda kalmadan çözer. **D3.8** Sahip olduğu fikirleri yeni durumlara uygular. **D3.9** Problem üzerinde çeşitli olasılıkları göz önünde bulundurarak ve sonuçları analiz ederek düşünür. **D3.10** Denemeler sırasında başarısız olduğunda, yeni bir tasarım yapmak istemek yerine mevcut tasarımını geliştirmeye odaklanır.
Yansıtıcı düşünme (D4)	**D4.1** Deneyimlerini ve düşüncelerini belgeler (dokümanlar aracılığıyla). **D4.2** Deneyimleri hakkında onları anlamak ve değerlendirmek için konuşur. **D4.3** Yetişkin desteği aracılığıyla kişisel deneyimlerini hatırlar ve sıralar. **D4.4** Günlük yaşam deneyimlerine yönelik bilgisini yeni durumlara uygular. **D4.5** Neler olup bittiği hakkında deneyime dayalı teoriler oluşturur.
İşbirlikçi düşünme (D5)	**D5.1** Başkalarının bir durumla ilgili duygularının kendisininkinden farklı olabileceğini fark ve kabul eder. **D5.2** Bir görev üzerinde grubun diğer üyeleri ile çalışırken (ebeveyni/yaşıtları) sırasını bekler. **D5.3** Görev üzerinde planlama yapmak, rolleri paylaşmak ve iş birliği yapmak için diğer grup üyeleri ile etkileşim kurar. **D5.4** Bir görev hakkındaki düşüncelerini grubun diğer üyeleriyle konuşur. **D5.5** Bir görevle ilgili sosyal çatışmaları çözmek için müzakere eder.

DUYGULAR BOYUTUNDA ÖĞRENME HEDEFLERİ

Kazanımlar	*Göstergeler*
F1: Bir mühendis gibi çalışmaktan hoşnut görünür.	**F1.1** Mühendislik etkinliklerine katılmaya hevesli ve istekli görünür. **F1.2** Etkinliklere sıkılmadan ve dikkati dağılmadan dahil olur.
F2: Yardıma ihtiyaç duyan insanlara veya karakterlere yardım etmekten hoşnut görünür.	**F2.1** Papağan ve arkadaşlarının sorunlarına ilgi gösterir. **F2.2** Kendisine sunulan probleme çözüm üretmekten memnun görünür.
F3: Etkinlikler sırasında ebeveyni ile çalışmaktan memnun görünür.	**F3.1** Anne ve/veya babası ile mühendislik tasarım sürecini deneyimlemekten memnun görünür.
F4: Etkinliklerde açık uçlu materyalleri kullanmaktan memnun görünür.	**F4.1** Tasarımında kullanmak üzere açık uçlu materyalleri keşfederken heyecanlıdır. **F4.2** Açık-uçlu materyallerle tasarım yapmaktan hoşnut görünür.
F5: Sunulan probleme çözüm ürettikleri için ebeveyni ve kendisi ile gurur duyar.	**F5.1** Anne ve/veya babası ile yaptığı tasarımı diğer gruplarla paylaşırken başarısından dolayı mutlu görünür. **F5.2** Tasarımının problemi nasıl çözeceğini diğer gruplara ve öğretmenine anlatırken mutludur.
F6: Mühendisliği olası bir kariyer alanı olarak görür.	**F6.1** İleride hangi mesleği yapmak istediği sorulduğunda mühendis olabileceğini söyler.

ÖĞRENME AKTİVİTELERİ

Müfredat kapsamındaki etkinliklerin tamamı mühendisliğe yönelik kazanım ve göstergelerin yanı sıra Okul Öncesi Eğitim Programımızda (MEB, 2013) yer alan aşağıdaki kazanım ve göstergelere hitap etmeyi amaçlamaktadır.

Bilişsel Gelişim	Dil Gelişimi	Sosyal-Duygusal Gelişim	Motor Gelişim
K1: Nesne/durum/olaya dikkatini verir. (Göstergeleri: Dikkat edilmesi gereken nesne/durum/olaya odaklanır. Dikkatini çeken nesne/durum/olaya yönelik sorular sorar. Dikkatini çeken nesne/durum/olayı ayrıntılarıyla açıklar.) K2 Nesne/durum/olayla ilgili tahminlerde bulunur. (Göstergeleri: Nesne/durum/olayla ilgili tahminini söyler. Tahmini ile ilgili ipuçlarını açıklar. Gerçek durumu inceler. Tahmini ile gerçek durumu karşılaştırır.) K3: Algıladıklarını hatırlar. (Göstergeleri: Nesne/durum/olayı bir süre sonra yeniden söyler. Hatırladıklarını yeni durumlarda kullanır.) K11: Nesneleri ölçer. (Göstergeleri: Standart olmayan birimlerle ölçer. Ölçme sonucunu söyler) K17: Neden-sonuç ilişkisi kurar. (Göstergeleri: Bir olayın olası nedenlerini söyler. Bir olayın olası sonuçlarını söyler.) K19: Problem durumlarına çözüm üretir. (Problemi söyler. Probleme çeşitli çözüm yolları önerir. Çözüm yollarından birini seçer. Seçtiği çözüm yolunun gerekçesini söyler. Seçtiği çözüm yolunu dener. Çözüme ulaşamadığı zaman yeni bir çözüm yolu seçer. Probleme yaratıcı çözüm yolları önerir).	K5: Dili iletişim amacıyla kullanır. (Göstergeleri: Konuşma sırasında göz teması kurar. Jest ve mimikleri anlar. Konuşurken jest ve mimiklerini kullanır. Konuşmayı başlatır. Konuşmayı dürdürür. Konuşmayı sonlandırır. Sohbete katılır. Konuşmak için sırasını bekler. Duygu, düşünce ve hayallerini söyler. Duygu ve düşüncelerinin nedenlerini söyler). K6: Sözcük dağarcığını geliştirir. (Göstergeleri: Dinlediklerinde yeni olan sözcükleri fark eder. Sözcükleri hatırlar ve sözcüklerin anlamını söyler. Yeni öğrendiği sözcükleri anlamlarına uygun kullanır). K10: Görsel materyalleri okur. (Göstergeleri: Görsel materyalleri inceler. Görsel materyalleri açıklar. Görsel materyallerle ilgili sorulara cevap verir).	K3: Kendini yaratıcı yollarla ifade eder. (Göstergeleri: Nesneleri alışılmışın dışında kullanır. Özgün ürünler taşıyan ürünler oluşturur). K7: Bir işi veya görevi başarmak için kendini güdüler. (Göstergeleri: Yetişkin yönlendirmesi olmadan bir işe başlar. Başladığı işi zamanında bitirmek için çaba gösterir). K12: Değişik ortamlardaki kurallara uyar. (Göstergeleri: İstekleri ve kurallar çeliştiğinde kurallara uygun davranır. Nezaket kurallarına uyar). K15: Kendine güvenir. (Göstergeleri: Grup önünde kendini ifade eder. Gerektiği durumlarda farklı görüşlerini söyler).	K4: Küçük kas kullanımı gerektiren hareketleri yapar. (Göstergeleri: Nesneleri kaptan kaba boşaltır. Nesneleri takar, çıkarır, ipe vb. Dizer. Nesneleri değişik malzemelerle bağlar. Malzemeleri keser, yapıştırır, değişik şekillerde katlar. Kalemi doğru tutar, kalem kontrolünü sağlar).

AKTİVİTELER

Etkinlik 1

Etkinlik Adı: Papağanın Islanmasın

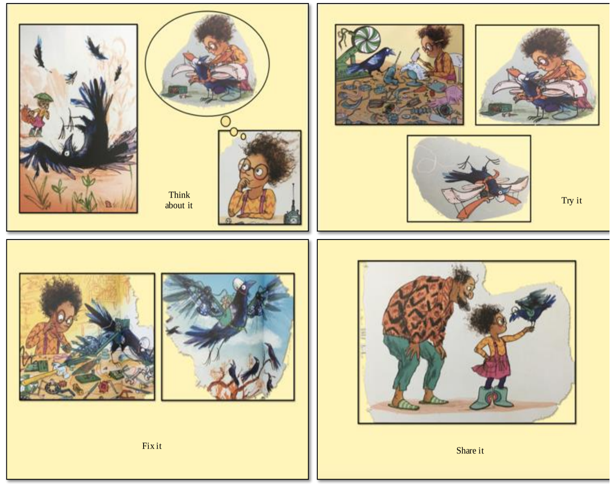
Odaklanılan Düşünme Becerisi: Meraklı Düşünme

Çocukların etkinliğe motive edilmesi: Papağan figürlü bir el kuklası aracılığıyla çocuklara problem durumu tanıtılır. Çocuklar yağan yağmur sularının papağanın evinin çatısından içeriye döküldüğünü ve papağanı ıslattığını, bunun papağan için bir problem teşkil ettiğini fark ederler. Çocuklar ebeveynlerinin rehberliğinde, papağanın evi için su geçirmeyen bir çatı yapmanın yollarını keşfederler.

Etkinliğin odağı: Papağan aslında bu sorunu çözebilmek için birkaç yol denemiş fakat başarısız olmuştur. "Su geçirmez bir çatı yapmanın yolları nelerdir?" bu etkinliğin odak sorusudur.

Kazanım ve göstergeler: K1.1, K1.2, K2.1, K2.2, K4.1, K4.2; S1, S2, S3, S4, S5, S6, S7; D1; F1, F2, F3, F4, F5, F6.

Kavramlar:	Mühendis, tasarım, plan, model, ıslak-kuru, kenar-köşe, düz-eğri.
Kullanılacak Materyaller:	• Papağan figürlü bir el kuklası • Açık uçlu çok sayıda materyal • Çocuklar ve ebeveynlerin tasarımlarının planını yaparken kullanmaları için beyaz çizim kağıtları • Çocukların ıslak ve kuru kavramlarını deneyimleyebilecekleri pek çok materyal (suyu emen pamuk, sünger, kumaş, tahta gibi materyaller ve suyu içine çekmeyen plastik, verniklenmiş ahşap gibi malzemeler). • Fotoğraf makinesi
Öğrenme Süreci	
Problem durumu çocuklara tanıtılır	Çocuklar ve ebeveynler atölyenin ilk haftasında birlikte mühendislik tasarım sürecini deneyimlemek için bir araya gelirler. Atölyenin açılışı ilk etkinlik olan "Papağan Islanmasın" isimli etkinlik ile yapılır. Etkinlik öncesinde çocuklara ve ebeveynlere bugün bir mühendis gibi çalışacakları söylenir. Sınıfta daha önce mühendislik mesleği ile ilgili konuşulmuşsa bir hatırlatma yapılır. Konuşulmamışsa, öğretmen çocuklara "*Çocuklar mühendisler ne iş yapar bilen var mı?*" sorusunu yöneltir. Çocukların cevapları dinlendikten sonra mühendisin kim olduğu ve mühendislerin ne iş yaptığı açıklanır.

	"Mühendisler tasarımlar yapan ve insanların problemlerine çözümler üreten kişilerdir. Mühendisler hayatımızı kolaylaştırmak için çalışırlar. Arabaları, telefonları, evleri, hatta sınıfımızda resim yaparken kullandığımız kalemleri bile mühendisler tasarlarlar."  Süreç çeşitli sorularla zenginleştirilir; • *"Sizce başka neleri mühendisler tasarlamış olabilir?"* • *"Peki, sizce yapraklar bir tasarım mıdır? Güneş bir tasarım mıdır? (Çocukların cevapları alındıktan sonra) Aslında bunların hiçbiri insanlar tarafından yapılmamıştır, bunlar doğal malzemelerdir."* • *"Sizin tanıdığınız bir mühendis var mı? Peki o neler tasarlıyor?"* Daha sonra öğretmen çocuklara "Mucit Gizmo" isimli resimli çocuk kitabını okur. *"Gizmo da bir mühendis gibi çalıştı. Gizmo ne yaptı? Kuş için yeni kanatlar yapmayı düşündü. Yeni kanatları yapıp denedi. Kuş ilk yapılan kanatlarla uçamadı. Daha sonra Gizmo "Acaba nerede hata yaptım, yaptığım kanatlar neden işe yaramamış olabilir?" diye düşündü. Daha sonra kuş için yeni kanatlar tasarladı ve bu yeni kanatlar da işe yaramadı. Ama Gizmo pes etmedi, bir daha düşündü, bir daha denedi ve bu kez başardı. Yeni kanatlar kuşun uçmasını sağladı. Sonra Gizmo kuş için yaptığı kanat tasarımını babası ile paylaştı."* *"Gizmo ne yaptı? Düşündü, denedi, geliştirdi ve paylaştı. Düşün, dene, geliştir, paylaş. Düşün, dene, geliştir, paylaş."* Öğretmen çocuklara bu döngünün basamaklarını resmeden 4 tane görseli teker teker göstererek tekrarlar. Daha sonra da çocuklara birlikte tekrarlamayı teklif eder. *"Siz de benimle söyler misiniz? Düşün, dene, geliştir, paylaş. Düşün, dene, geliştir, paylaş."* Her bir çocuğun görselleri incelediğinden ve mühendislik tasarım döngüsüne ait resim sıralamasını doğru şekilde yaptığından emin olunduktan sonra öğretmen, *"Şimdi sizi bir arkadaşımla tanıştıracağım." (Papağan figürlü el kuklası etkinlik öncesinde fark edilebilir şekilde ıslatılır ve daha sonra papağan kendini çocuklara tanıtır). "Merhaba çocuklar ve onların sevgili anne babaları. Sizi burada görmek ne güzel. Benim adım Papağan."*

Bu sırada çocuklardan papağana neden ıslak olduğunu sormaları beklenir. Eğer sorulmadıysa, öğretmen;

"Papağan bugün her zamankinden biraz farklı görünüyorsun. Çocuklar sizin de dikkatinizi çeken bir şey oldu mu?"

Çocukların cevapları dinlenir ardından papağan cevap verir:

"Çocuklar bir bilseniz başıma neler geldi. Biliyorsunuz şimdi ilkbahar mevsimindeyiz ve bu mevsimde çok yağmur yağıyor. İşte, bugün evimde rahat koltuğumda oturup kitabımı okuyorken başıma su damlaları düşmeye başladı. Önce 1 damla, sonra 2, sonra 3, 4,5,6,7, 8... Sonra da işte böyle sırılsıklam oldum."

Çocukların yağmur sularının çatıdaki büyük delikten evin içine akmasının papağan için bir problem olduğunu fark etmeleri sağlanır. Öğretmen çocuklara çatının ne olduğu ve işlevi hakkında sorular sorar. Çatıya neden ihtiyaç duyulduğu sorulur. Farklı yapıların çatılarını (ev çatısı, kümes çatısı, okul çatısı, cami çatısı vb.) örnekleyen görseller incelenir (Acer & Gözen, 2013). Bu çatıların yapıları hakkında konuşulur (*Neden bazı evlerin çatıları üçgen şeklinde? Neden aşağıya doğru? Neden bazı evlerin çatıları düz?*).




Daha sonra tüm velileri ve çocukları sınıfın ortasına davet eder. Sınıfın ortasında toplanan veliler ve çocuklar çember oluşturacak şekilde ayakta dururlar, el ele tutuşur ve her iki ellerini ortada birleştirirler. Öğretmen papağandan da onlara katılmasını ister ve papağanı çemberin ortasına bırakır. Çocuklara, hep birlikte bir çatı oluşturdukları söylenir. Peki bu çatı papağanı yağmurdan, rüzgârdan, kardan koruyabilecek midir, onu sıcak tutup ve üzerini örtebilecek midir? Tüm gruplar tekrar yerlerine geçtikten sonra papağanın evi ve bu evin çatısı incelenir. Öğretmen papağanın evini çocuklara gösterir ve problem durumunu özetler;

"Çocuklar işte bu da papağanın evi. Baksanıza papağan ıslanmış, anlaşılan onun çatısı artık onu yağmurdan koruyamıyor."

Papağanın evinin çatısı kâğıttan yapılmıştır. Üstelik üzerinde de kocaman bir delik açılmıştır. Çocuklara bu çatının neden papağanı yağmurdan koruyamamış olabileceği sorulur.

Çocukların problem-çözme amacını anlamalarına yardım edilir.	Çocuklar ve ebeveynlere papağanın bu problemi çözmek için neler yapabileceği sorulur. Fikirler yazı tahtasına üzerine fikri öneren çocuğun ismi ile not edilir (eğer mümkünse öğretmen her bir fikri temsil eden görseller çizer). Daha sonra papağan; *"Çocuklar, aslında benim bu problemi çözmek için bir fikrim var. Bence benim güzel yuvamın çatısının üzerine şu kumaşı serelim. Ne dersiniz, çatıya kumaş sersek bu sorunu çözebilir miyiz?"* Öğretmen çocuklara papağanın evini gösterir ve çocuklardan bu çözüm yolunun papağanın problemini çözüp çözmeyeceğini tahmin etmelerini ister. Oylama yapılır: *"Çocuklar sizce çatıya kumaş serersek bu problemi çözebilir miyiz?"* Çatıya kumaş sermenin papağanın yağmur problemini neden çözebileceği veya çözemeyeceği birkaç çocuğa sorulur ve cevapları dinlenir. Daha sonra bir kumaş papağanın evinin çatısına serilir ve üzerine yağmur yağıyormuşçasına su damlatılarak bu çözümün problemi çözüp çözmeyeceği test edilir. Bu çözüm belki yağmur az yağdığında işe yarayabilir fakat yağmur oranı arttığında işe yaramayacaktır.
Mevcut materyaller keşfedilir ve sınırlılıklar belirlenir.	Öğretmen çocuklar ve ebeveynlere mühendislerin karar vermeden önce sınırlılıkları belirlediklerini söyler. İlk sınırlılık çatının su geçirmeyecek olması gerektiğidir. Bu nedenle her bir öğrenme grubuna kullanmayı planladığı materyal ve neden bu materyali kullanmak istediği sorulur. Daha sonra her bir çocuk açık uçlu materyaller arasından kullanmayı planladığı materyali seçip bu materyali sınırlılıklar açısından (su geçirip geçirmemesi açısından) test eder ve gözlemler. Her bir ebeveyn-çocuk çalışma grubundan materyallerin yapıldıkları malzemeler ve hangi malzemelerin (plastik, cam, ahşap, sünger...) su geçirip hangilerinin geçirmediği hakkında konuşmaları istenir. Öğretmen bu süreçte her grubu gözlemler. Bir diğer sınırlılık ise çatının papağanın evini tamamen kaplayacak uzunluk ve genişlikte olması gerektiğidir. Bunun için ebeveynler ve çocuklar kuş evinin tavan kısmının boyutlarını standart ya da standart olmayan ölçe araçlarını kullanarak ölçebilirler. Bu ölçme işlemi sırasında ebeveyn ve çocuklar gözlemlenir. Ölçme işlemini ne şekilde yaptıkları, hangi ölçme aracını kullandıkları ve ölçüm sonucunu tasarımlarına ne şekilde yansıttıkları gözlemlenir. Örneğin, bir grup çatının uzunluğunu ellerindeki kalemin 2,5 katı olarak ölçmüş olabilir ve çatı tasarımlarında da bu sonucu kullanacaktır. Bu sayede çocuklar mühendislerin çeşitli sınırlılıklara sahip olduklarını ve tasarımlarıyla ilgili bir karar vermeden önce bu sınırlılıklara ait kriterleri karşılayıp karşılamadıklarını incelemeleri gerektiği fikrini benimserler.
Fikirler planlar ve modeller (prototip) ile temsil edilir.	Sınırlılıklar belirlendikten sonra ebeveynler ve çocuklar kendi tasarımları üzerine tekrar düşünmeye başlarlar. Bu noktada her gruba çizim kağıtları dağıtılır ve çocuklar ve ebeveynlerden papağan için nasıl bir çatı tasarlayacaklarını planlayıp taslaklarını çizmeleri istenir. Ebeveynler çocuklarının planlarıyla ilgili çizim yapmalarına, fikirlerini sözlü olarak dile getirmelerine rehberlik eder, plana dair sözel açıklamalarını not ederler. Çocuklar çizimlerini bitirdiklerinde öğretmen tek tek yanlarına gider ve çocuğun problem durumunu anlayıp anlayamadığını çeşitli sorular aracılığıyla test eder. Örneğin; *"Sen papağanın bir problemini çözmek için düşündün ve bu planı çizdin öyle değil mi? Peki papağanın bu haftaki problemi neymiş?"*

	"Papağan bu hafta bizden hangi konuda ona yardım etmemizi istiyor?" Çocuğun planıyla ilgili detayları anlatmasını sağlamak için sorulabilecek sorular aşağıda örneklendirilmiştir. *"Nasıl bir çatı yapmayı planlıyorsun?"* *"Senin çatın hangi malzemeden yapılmış olacak?"* *"Çatının şekli nasıl olacak?"* *"Seni mezurayla ölçüm yaparken görmüştüm. Çatının boyu kaçmış? Enini kaç santimetre buldun?"* Çizilen planlar daha sonra süreci gözden geçirmek için kullanılmak üzere saklanır. Öğretmen ebeveyn ve çocuklara ürettikleri bu fikirlerin problemi çözüp çözmeyeceğini görmeleri için, tıpkı mühendislerin yaptığı gibi, bu fikirleri yansıtan birer model inşa etmelerinin iyi bir fikir olacağını söyler. Daha sonra gerçek bir yapının modelini yapmanın ne anlama geldiği üzerine konuşulur *"Mühendisler tasarımlarını gerçeğe dönüştürmeden önce bu tasarımların modellerini yaparlar. Mesela bir apartmanı inşa etmeden önce onun küçük bir modelini yaparlar. Apartmanın gerçek halinin nasıl görüneceğine, hangi malzemelerin kullanacağına bu modeli test ederek karar verirler. Yani, model tasarımların gerçekte soruna çözüm olup olamayacağını görüp anlamamızı sağlar."* Her bir grup bir önceki aşamada test ettiği ve kullanmaya karar verdiği açık uçlu materyali kullanır. Oluşturduğu modeli deneyen çocuk bu sayede tasarımında hangi materyali kullanacağına ve tasarımının nasıl görüneceğine dair daha net bir fikir geliştirebilir. Çocuklara mühendislerin problemleri çözmeye çalışırken neler yaptıklarını kendilerine ve başka insanlara hatırlatması için yazdıkları ya da resim çizerek anlattıkları hatırlatılır. Mühendislerin bu yüzden not defterlerini kullandıklarından bahsedilir *"Şimdi biz de modelimizi test denemeden önce fotoğrafını çekelim ve mühendislik defterimize ekleyelim. Tasarımlarınızı denemeden önce ve denedikten sonra fotoğraflarını çekeceğiz. Bu fotoğraflarla "mühendislik defterlerimizi" oluşturacağız. Böylece, yaptığımız hiçbir şeyi unutmayacak ve tasarımlarımızı daha da geliştireceğiz."* Her grup için ayrı ayrı mühendislik defteri tutulur. Çocukların plan ya da taslaklarına ait çizimler ya da yazılı ifadeler, modellerinin deneme öncesi ve sonrası çekilmiş fotoğrafları, modelin geliştirildikten sonraki halini gösteren fotoğrafları ve tasarımın ilk ve son hallerinin fotoğrafları her grubun kendi mühendislik defterine eklenir.

Modeller test edilir.	Tüm modeller denenmeden önce fotoğraflanır. Her grup oluşturduğu modeli sınırlılıklar ve problemi çözüp çözmediği açısından test eder. Gruplar modellerini test ettikten sonra geliştirmek konusunda desteklenir. Tasarımlarının çalışıp çalışmayacağı konusunda sorgulama ve merak etme açısından çocuklara model olunur. Öğretmen; *“Kartondan yapılmış bir çatı, yağmur yağdığında su damlalarının evin içine akmasını önler mi merak ediyorum.”* *“Su düz bir çatıdan mı yoksa eğimli bir çatıdan mı daha kolay akar?”*
Tasarımlar inşa edilir.	Modeller test edildikten sonra, her grubun kafasında gerçek tasarımlarında hangi materyalleri kullanacaklarının netleşmesi beklenmektedir. Bunun yanı sıra, çocuklar modeller üzerinde yaptıkları çeşitli deneme yanılmalar sonucunda gerçek tasarımlarının nasıl görüneceği ve nasıl bir sistem oluşturmaları gerektiği hakkında daha net fikirlere sahip olacaktır. Modeller üzerinde yapılan deneme yanılmalar doğrultusunda her grup tasarımında kullanacağı malzemeleri seçer. Öğretmen her bir çocuğa neden bu malzemeyi/malzemeleri seçtiğini sorar. Daha sonra her bir grup kendi tasarımını inşa etmeye başlar.
Tasarımlar denenir.	Her grup kendi tasarımının problemi çözüp çözmeyeceğini dener. Bu sırada öğretmen grupların tasarımını test etme sürecini tek tek her grubu dolaşarak gözlemler. Çocukların ve ebeveynlerinin ne olduğunu tanımlamalarına çeşitli sorular aracılığıyla yardımcı olunur. Örneğin; • *"Ne oldu?",* • *"Ne fark ettin?",* • *"Tekrar denemek ister misin?"* Ne olduğu tanımlandıktan sonra bunun neden olduğu yönündeki fikirleri alınır. Örneğin; • *“Sence neden olmadı, problem nerede olabilir?”* • *"Sence bu çatı neden su geçirmiş olabilir?"* • *"Çatıyı neden eğimli/düz yaptın?"* • *"Sence bu çatı yağmur sularının evin içine girmesini önleyebilecek mi?”* • *"Şimdi ne yapmayı planlıyorsun?"* • *“Tasarımını geliştirmek için neye ihtiyacın var?"*
Tasarımlar denemeler sonrasında geliştirilerek tekrar denenir.	Her grup tasarımlarını test edip sonuçları gördükten sonra, tasarımları üzerine tekrar düşünür ve tasarımlarını geliştirir. Etkinlik süresince çocuklar ve ebeveynlere farklı materyaller kullanarak çatı tasarımlarını geliştirmeleri ve tekrar tekrar denemeleri için fırsat verilir.

<table>
<tr>
<td>Değerlendirme: Tüm çocukların ve ebeveynlerin deneyimlerini birbirleriyle paylaşmaları ve birbirlerinden öğrenmeleri için fırsat verilir.</td>
<td>Gün sonunda tüm çocuklar ve ebeveynlerin dahil olacağı bir tartışma ortamı yaratılır. Her ebeveyn-çocuk grubundaki çocuk sırayla herkesin görebileceği bir yere gelir ve tasarım sürecini diğer gruplarla paylaşır. Sunum yapan çocuk ilk prototipinde kullanmayı planladığı materyallere ve tasarım sürecinin başında ne tür bir tasarım yapmayı planladığına değinerek hem çizdiği planı ve hem de modelini diğer gruplara gösterir. Sunum yapan çocuğun aynı zamanda ilk ve son prototipi arasındaki farklılıklara değinerek tasarımını süreçte nasıl geliştirdiğini açıklaması beklenir. Bu sırada, öğretmen sunum yapan çocuğa çeşitli sorularla rehberlik eder. Öğretmen tarafından bu aşamada sorulabilecek sorular aşağıda örneklendirilmiştir.

“Sence tasarımın papağanın problemini çözdü mü?”
“Bu problemi çözmek için ilk önce ne yaptın?”
“Planında neler çizdin?"
“Planını çizdikten sonra ne yaptın?”
“Modelini üzerine su sıkarak denediğini hatırlıyorum. Neler oldu anlatır mısın? Çatı modelin su geçirdi mi?”
“Modelinde hangi malzemeleri kullanmıştın?” ya da
“Modelini havlu kâğıt rulolarıyla (çocuk hangi materyali kullanmışsa) yaptığını hatırlıyorum. Peki bu modeli üzerine su sıkıp denedin mi?”
“Tasarımında neden bu malzemeyi kullandın?”
“Neden tasarımını yaparken modeldekinden başka bir malzeme kullandın? Neden tasarımını da havlu kâğıt rulosu (çocuk hangi materyali kullanmışsa) ile yapmadın?”
“Eğer biraz daha zamanımız olsaydı, tasarımını geliştirmek ister miydin?”
“Bu tasarımı biraz daha geliştirecek olsan başka neler yapardın?”

Tüm gruplar birbirlerinin sunumlarını dinlemek ve bu sayede bir probleme birden çok çözüm üretilebileceğini görmek için teşvik edilir. Çocuklar ayrıca birbirlerinin tasarımlarına yorum yapma, tasarımları daha da geliştirmek için birbirlerine fikir verme konusunda desteklenir. Daha sonra, su geçirmez bir çatı inşa etmenin yollarının neler olduğu üzerine konuşulur ve öğrenilenler özetlenir. Aktivitenin sonunda papağan görünür ve tüm çocuk ve ebeveynlere kendisine yardım ettikleri için teşekkür eder.</td>
</tr>
</table>

Ev-temelli aile katılımı etkinliği	Öğretmen etkinlik sonunda ebeveynlere üzerinde aşağıdaki metnin yazılı olduğu bir not kâğıdı verir. ***Sayın Velim*** *Mühendislik eğitimine yönelik ilk etkinliğimiz sona erdi. Umarız hem sizin açınızdan hem de çocuğunuz açısından verimli bir etkinlik olmuştur. Önümüzdeki hafta yeni bir etkinlik için sizlerle bir araya geleceğiz. Bu hafta öğrendiklerimizin pekişmesi açısından sizden küçük bir isteğim olacak. Lütfen hafta içerisinde çocuğunuzla birlikte etrafınızda (evinizde, televizyonda, sınıfta veya doğada) gördüğünüz herhangi bir teknoloji ile ilgili eğlenceli bir bilmece uydurun. Bu teknolojiyi hangi mühendislik dalının üretmiş olabileceğini çocuğunuzla birlikte araştırın. Bu sırada lütfen iskele yönteminin ilkelerini hatırlayalım. İkinci etkinliğe geçmeden önce çocuğunuzla birlikte bu bilmeceyi bütün sınıfa soralım ve görelim bakalım sorduğunuz teknolojiyi tahmin edebilecekler mi ☺.*

<table>
<tr><td colspan="2">ETKİNLİK 2</td><td rowspan="4"></td></tr>
<tr><td colspan="2">Etkinlik Adı: Kaplumbağa Nehri Geçebilecek Mi?</td></tr>
<tr><td colspan="2">Odaklanılan Düşünme Becerisi: Israrcı Düşünme</td></tr>
<tr><td colspan="2">Çocukların etkinliğe motive edilmesi: Papağan ve kaplumbağa figürlü el kuklaları aracılığıyla çocuklara problem durumunu tanıtılır. Çocuklar papağanı ziyarete gelen kaplumbağa yol üzerindeki köprü yıkıldığı için evine geri dönememesinin kaplumbağa için bir problem teşkil ettiğini fark ederler. Çocuklar ebeveynlerinin rehberliğinde, kaplumbağanın tekrar evine dönebilmesi için nehrin üzerine sağlam bir köprü inşa etmenin yollarını keşfederler.</td></tr>
<tr><td colspan="3">Etkinliğin Odağı: Kaplumbağa ve papağan aslında bu sorunu çözebilmek için birkaç yol düşünmüş, tüm bu yolları test etmiş fakat başarısız olmuştur. Bu etkinlik “Sağlam bir köprü inşa etmenin yolları nelerdir?” sorusuna ve çocukların köprü inşa etmeye yönelik fikirlerinin tekrarlayan inşa etme ve test etme sürecine odaklanmaktadır. Bu etkinlikte amaç mükemmel bir köprü inşa etmek değil, çocukların tasarımlarını geliştirmenin yollarını keşfedebilmesi ve tasarımlarını iyileştirmek için ısrarcı olmalarıdır.</td></tr>
<tr><td colspan="3">Kazanım ve göstergeler: K1.1, K1.2, K2.1, K2.2, K3.1, K3,2, K5.1, K5.2; S1, S2, S3, S4, S5, S6, S7; D2; F1, F2, F3, F4, F5, F6.</td></tr>
<tr><td>Kavramlar:</td><td colspan="2">Mühendis, tasarım, plan, model, ıslak-kuru, kenar-köşe, düz-eğri, altında-üstünde, geniş-dar, uzun-kısa.</td></tr>
<tr><td>Kullanılacak Materyaller:</td><td colspan="2">• Papağan figürlü bir el kuklası
• Açık uçlu çok sayıda materyal
• Çocuklar ve ebeveynlerin tasarımlarının planını yaparken kullanmaları için beyaz çizim kağıtları
• Fotoğraf makinesi</td></tr>
<tr><td colspan="3">Öğrenme Süreci</td></tr>
<tr><td>Problem durumu çocuklara tanıtılır</td><td colspan="2">Atölyenin ikinci haftasında “Kaplumbağa Nehri Geçebilecek Mi?” isimli etkinlik gerçekleştirilecektir. Öncelikle geçen hafta neler yapıldığı hatırlanır. Mühendislerin neler yaptıkları ve çalışırken hangi adımları izledikleri hakkında konuşulur. Bu aşamada her çocuktan kendi mühendislik defterini incelemesi ve neler yaptığını hatırlaması istenir. Süreç farklı mühendislik alanlarına değinen aşağıdaki sorularla zenginleştirilebilir;
• “Çocuklar mühendislerin işi/görevi neydi hatırlayan var mı?”
Bir önceki hafta etkinlik sonunda, her çocuk ve aileye ev ödevi olarak çevrelerinde gördükleri veya günlük yaşamlarında kullandıkları herhangi bir teknolojiyle ilgili bir bilmece türetmeleri ve bu teknolojiyi hangi mühendislik alanda çalışan mühendisin yapmış olabileceğini araştırmaları</td></tr>
</table>

istenmişti. Gruplar sırasıyla diğer gruplara türettikleri bu bilmeceyi sorar, cevaplar üzerine konuşulur. Daha sonra etkinliğe aşağıdaki sorularla devam edilir.

- *"Sizce sizin evdeki başka neleri mühendisler tasarlamış olabilir?"*
- *"Sizce mühendisler ilaçların üretilmesinde de görev yapar mı?"*
- *"Peki ilaçlar hayatımızı kolaylaştırır mı? Nasıl?"*
- *"Peki bilgisayarlar bir tasarım mıdır? Bilgisayarlar hayatımızı kolaylaştırır mı?"*
- *"Bilgisayarları hangi mühendisler tasarlamış olabilir?"*
- *"Bilgisayar mühendisleri ne iş yapar?"*
- *"Başka ne mühendisleri olabilir?"*
- *"İnşaat mühendisi, çevre mühendisi, makine mühendisi, kimya mühendisi, elektrik-elektronik mühendisi ne iş yapıyor olabilir?"*
- *"Eski zamanlarda yaşayan insanların evleri var mıydı? Nerede yaşıyorlardı? Orada yaşamak mı şimdiki gibi evlerimizde yaşamak mı daha kolay?"*
- *"Peki onların telefonları var mıydı? Nasıl haberleşiyorlardı? Haberleşmek şimdi mi daha kolay o zaman mı daha kolaydı?"*
- *"Onların ilaçları var mıydı? Hasta olduğunda iyileşmek şimdi mi daha kolay o zaman mı daha kolaydı?"*

Önceki öğrenmeler hatırlandıktan sonra, papağan tekrar görünür;

"*Merhaba çocuklar. Sizi tekrar görmek harika. Bugün size bir sürprizim var. Sizi çok sevdiğim biriyle tanıştıracağım." Bu sırada kaplumbağa figürlü el kuklası görünür ve "Merhaba çocuklar. Nasılsınız? Sizinle tanıştığıma çok memnun oldum." Çocuklar başıma neler geldi bir bilseniz."*

Papağanın çok sevdiği arkadaşı kaplumbağa onu ziyarete gelmiştir. Fakat kaplumbağanın evi ile papağanın evi arasındaki köprü o geldikten sonra yıkılmıştır. Kaplumbağa ve papağan kaplumbağanın nehri yüzerek geçmesinin iyi bir çözüm yolu olacağını düşünürler. Kaplumbağa yüzebilir ama köprünün altından uzunca bir nehir geçmektedir. Yaşlı kaplumbağanın bu uzun nehri hiç dinlenmeden yüzmesi çok olur ve daha nehrin yarısına bile varamadan papağanın yanına geri döner. Papağanın aklına bir fikir daha gelir, evinde bulduğu uzun bir çubuğu nehir kıyısına koyacak ve kaplumbağa da bu çubuğun üzerinde yürüyerek karşıya geçecektir. Fakat çubuk çok incedir ve kaplumbağa onun üzerinde yürüyemez. Bu etkinlikle, çocukların, papağan ve kaplumbağanın evleri arasındaki nehri geçmeye yarayan köprünün yıkılmasının kaplumbağa için bir problem olduğunu fark etmeleri ve bu probleme çözüm önerileri getirmeleri sağlanır.

<table>
<tr>
<td>Çocukların problem-çözme amacını anlamalarına yardım edilir.</td>
<td>
Papağan;
“Arkadaşım kaplumbağaya sizin birer mühendis olduğunuzu, geçen hafta ailelerinizle birlikte benim evime su geçirmez bir çatı yaptığınızı anlattım. Ne dersiniz bugün de bir mühendis gibi çalışıp nehrin üzerine köprü inşa ederek bize yardım edebilir misiniz?”.
Öğretmen;
“Çocuklar mühendislik yapmaya hazır mısınız? Ama önce biraz düşünelim
“Sizce köprüler ne işe yarar?”
“Daha önce köprü gören var mı?”
“Gördüğün bu köprüden kimler geçiyordu?”
“Köprülerden başka kimler geçer?”
“Köprüleri hangi mühendisler yapar?” (Inşaat mühendisleri).

Daha sonra, çocuklara farklı köprü türlerine ait görseller gösterilir ve bu görseller üzerinde tartışılır.

“Sizce bu köprü ne için yapılmış?”
“Bu köprüden kimler geçiyor olabilir?”

“Sizce bu köprü ne için yapılmış?”
“Bu köprüden kimler geçiyor olabilir?”
</td>
</tr>
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“Peki sizce bu köprüden kimler geçiyor olabilir?”
“Sizce bu köprü neden bu kadar yüksek?”
“Bu köprü olmasaydı ne olurdu?”

“Sence bu teyzelerin üzerinde yürüdükleri şey de bir köprü müdür?”
“Bu köprüyü de mi mühendisler inşa etmiştir?”

“Peki sizce bu resimdeki de bir köprü müdür?”
“Köprüler sadece suları geçmek için mi yapılır?”;
“Üst geçitler de insanların, hayvanların, taşıtların bir yerden başka bir yere geçmesini sağlar mı?”.
“Bu köprü olmasaydı ne olurdu?”

Görsellerde yer alan farklı köprü türlerinin özellikleri hakkında konuşulur. Çocukların verdikleri cevaplar üzerine tartışılır. Daha sonra etkinliğe başlanır ve ilk olarak çocuklar ve ebeveynlere kaplumbağayı nehirden kaşıya geçirmek için köprü inşa etmekten başka fikirleri olup olmadığı sorulur. Fikirler yazı tahtasına not edilir (eğer mümkünse öğretmen her bir fikri temsil eden görseller çizer).

Mevcut materyaller keşfedilir ve sınırlılıklar belirlenir.	Öğretmen çocuklar ve ebeveynlere mühendislerin karar vermeden önce sınırlılıkları belirlediklerini tekrar hatırlatır. Bu etkinlikte ilk sınırlılık **kaplumbağanın nehirden karşıya suya düşmeden geçmesi** gerektiğidir. Bunun için tasarlanan köprünün veya kayığın vs. **kaplumbağanın ağırlığını taşıyacak sağlamlıkta olması** gerekmektedir. Bunun yanı sıra, eğer köprü inşa edilecekse bu köprü **nehri boydan boya kaplayacak uzunlukta ve kaplumbağanın geçebileceği genişlikte** olmalıdır. Bunun için ebeveynler ve çocuklar nehrin uzunluğunu ve kaplumbağanın genişliğini standart ya da standart olmayan ölçme araçlarını kullanarak ölçebilirler. Bu sayede çocuklar mühendislerin çeşitli sınırlılıklara sahip olduklarını ve tasarımlarıyla ilgili bir karar vermeden önce bu sınırlılıklara ait kriterleri karşılayıp karşılamadıklarını incelemeleri gerektiği fikrini benimserler. Sınırlılıklar belirlendikten sonra ebeveynler ve çocuklar kendi tasarımları üzerine tekrar düşünmeye başlarlar ve ne tasarlayacakları konusunda karar verirler. Bu noktada her gruba büyük fon kartonları dağıtılır ve çocuklar ve ebeveynlerden kaplumbağayı nehirden karşıya güvenle geçirebilmek için nasıl bir köprü vs. tasarlayacaklarını planlayıp taslaklarını çizmeleri istenir. Bu taslaklar daha sonra süreci gözden geçirmek için kullanılmak üzere saklanır.
Fikirler planlar ve modeller (prototype) ile temsil edilir.	Sınırlılıklar belirlendikten sonra ebeveynler ve çocuklar kendi tasarımları üzerine tekrar düşünmeye başlarlar. Bu noktada her gruba çizim kağıtları dağıtılır ve çocuklar ve ebeveynlerden papağan için nasıl bir çatı tasarlayacaklarını planlayıp taslaklarını çizmeleri istenir. Ebeveynler çocuklarının planlarıyla ilgili çizim yapmalarına, fikirlerini sözlü olarak dile getirmelerine rehberlik eder, plana dair sözel açıklamalarını not ederler. Çocuklar çizimlerini bitirdiklerinde öğretmen tek tek yanlarına gider ve çocuğun problem durumunu anlayıp anlayamadığını çeşitli sorular aracılığıyla test eder. Örneğin; *“Sen papağanın bir problemini çözmek için düşündün ve bu planı çizdin öyle değil mi? Peki papağanın bu haftaki problemi neymiş?”* *“Papağan bu hafta bizden hangi konuda ona yardım etmemizi istiyor?”* Çocuğun planıyla ilgili detayları anlatmasını sağlamak için sorulabilecek sorular aşağıda örneklendirilmiştir. • “*Seninki nasıl bir köprü olacak?”* • *“Hangi malzemeleri kullanmayı planlıyorsun?”* • *“Neden köprünü yaparken ... (çocuğun kullanacağını söylediği materyal) kullanmanın iyi bir fikir olduğunu düşündün?* • *“Köprünün şekli nasıl olacak?”* • *“Seni mezurayla ölçüm yaparken görmüştüm. Nehrin uzunluğu kaçmış? Genişliğini kaç santimetre buldun?”* Çizilen planlar daha sonra süreci gözden geçirmek için kullanılmak üzere saklanır. Öğretmen, ebeveyn ve çocuklara ürettikleri bu fikirlerin problemi çözüp çözmeyeceğini görmeleri için, tıpkı mühendislerin yaptığı gibi, bu fikirleri yansıtan birer model inşa etmelerinin iyi bir fikir olacağını söyler. Daha sonra gerçek bir yapının modelini yapmanın ne anlama geldiği üzerine tekrar konuşulur. Her bir grup bir önceki aşamada test ettiği ve kullanmaya karar verdiği açık uçlu materyali kullanır. Oluşturduğu modeli deneyen çocuk bu sayede tasarımında hangi materyali kullanacağına ve tasarımının nasıl görüneceğine dair daha net bir fikir geliştirebilir. Çocuklara mühendislerin

	problemleri çözmeye çalışırken neler yaptıklarını kendilerine ve başka insanlara hatırlatması için yazdıkları ya da resim çizerek anlattıkları hatırlatılır. Mühendislerin bu yüzden not defterlerini kullandıklarından bahsedilir *“Şimdi biz de modelimizi test denemeden önce fotoğrafını çekelim ve mühendislik defterimize ekleyelim. Tasarımlarınızı denemeden önce ve denedikten sonra fotoğraflarını çekeceğiz. Bu fotoğraflarla “mühendislik defterlerimizi” oluşturacağız. Böylece, yaptığımız hiçbir şeyi unutmayacak ve tasarımlarımızı daha da geliştireceğiz.”* Çocukların plan ya da taslaklarına ait çizimler ya da yazılı ifadeler, modellerinin deneme öncesi ve sonrası çekilmiş fotoğrafları, modelin geliştirildikten sonraki halini gösteren fotoğrafları ve tasarımın ilk ve son hallerinin fotoğrafları her grubun kendi mühendislik defterine eklenir.
Modeller test edilir.	Öğretmen; *“Modelini inşa ettiğiniz köprülerin kaplumbağanın problemini çözüp çözemeyeceğini merak ediyorum. Test etmek için bir yol bulmalıyız. Nasıl test edebileceğimiz konusunda ne düşünüyorsunuz?”* Çocuklara modellerini test etmek için bir yol bulmalarında yardımcı olunur. Aşağıdaki öneriler sunulabilir; • *“Köprü nehri geçmeye yetecek kadar uzun mu? Köprü kaplumbağanın geçebileceği kadar geniş mi?”* • *“Köprü kaplumbağanın ağırlığını taşıyabilecek kadar sağlam mı?”* Çocuklar ve ebeveynleri inşa ettikleri modelleri tamamlamış göründüklerinde sistemlerini test etmelerine yardımcı olunur ve yapılarının testi geçip geçemediğini, geçemediyse neden geçememiş olabileceği, geçtiyse neden geçmiş olabileceği değerlendirilir. Test etme aşamasında öğretmen çocuklar ve ebeveynlerini tekrar tekrar denemeye teşvik etmelidir. Öğretmen çocuklara, gerçek mühendislerin de modeller üzerinde çalıştıklarını, bu modelleri sürekleri test ettiklerini ve bu denemeler sonucunda tasarımlarını geliştirdiklerini söyler. Gruplar modellerini test ederken karşılaşabilecekleri olası bir başarısızlık durumunda yeni çözümler üretmeleri için teşvik edilirler. Modellerini sınırlılıklar açısından test eden çocuklar ve ebeveynler bu deneyimlerinin olumlu veya olumsuz sonuçları doğrultusunda modellerini geliştirme yoluna giderler. Bir grubun tasarımı ilk denemede testi geçerse bu grup başka bir tasarım fikri ile zorlanır.
Tasarımlar inşa edilir.	Modeller test edildikten sonra, her grubun kafasında gerçek tasarımlarında hangi materyalleri kullanacaklarının netleşmesi beklenmektedir. Bunun yanı sıra, çocuklar modeller üzerinde yaptıkları çeşitli deneme yanılmalar sonucunda gerçek tasarımlarının nasıl görüneceği ve nasıl bir sistem oluşturmaları gerektiği hakkında daha net fikirlere sahip olacaktır. Modeller üzerinde yapılan deneme yanılmalar doğrultusunda her grup tasarımında kullanacağı malzemeleri seçer. Öğretmen her bir çocuğa neden bu malzemeyi/malzemeleri seçtiğini sorar. Daha sonra her bir grup kendi tasarımını inşa etmeye başlar.

Tasarımlar denenir.	Çocuklar ve ebeveynlerine gerçek yapılarının ilk halini test ettikten sonra tekrar deneyebilecekleri, bu yapıları geliştirdikten sonra tekrar test edebilecekleri anlatılır. Her grup tasarımlarını test edip sonuçları gördükten sonra, tasarımları üzerine tekrar düşünür ve tasarımlarını geliştirir. Gün boyunca çocuklar ve ebeveynlere farklı materyaller kullanarak papağanın evi için çatı tasarlamaları ve tekrar tekrar denemeleri için fırsat verilir. Tüm test etme süreçlerinin öncesinde ve sonrasında inşa edilen yapılar fotoğraflanır. İsteğe bağlı olarak ebeveynler ve çocuklar köprülerinin en fazla ne kadar ağırlık taşıyabileceğini çeşitli ağırlıktaki nesneler aracılığıyla test edebilirler. Çocukların ne olduğunu tanımlamalarına çeşitli sorular aracılığıyla yardımcı olunur. Örneğin; • *"Ne oldu?",* • *"Ne fark ettin?",* • *"Tekrar denemek ister misin?"* Ne olduğu tanımlandıktan sonra bunun neden olduğu yönündeki fikirleri alınır. Örneğin; • *"Sence bu köprünün kaplumbağa üzerinden geçerken yıkılmasının sebebi ne olabilir?"* • *"Kaplumbağanın bu köprüden güvenle karşıya geçmesinin sebebi sence ne olabilir?"* • *"Neden köprünü düz/kavisli vs. yaptın?"* • *"Neden pipetleri (çocuğun kullandığı malzeme hangisi ise) köprünün ayakları olarak kullandınız?"* • *"Şimdi ne yapmayı planlıyorsun?"* • *"Bu köprüyü sağlamlaştırmak için bir fikrin var mı? Neler yapabilirsin?"*
Tasarımlar denemeler sonrasında geliştirilerek tekrar denenir.	Her grup tasarımlarını test edip sonuçları gördükten sonra, tasarımları üzerine tekrar düşünür ve tasarımlarını geliştirir. Etkinlik süresince çocuklar ve ebeveynlere farklı materyaller kullanarak çatı tasarımlarını geliştirmeleri ve tekrar tekrar denemeleri için fırsat verilir.

Değerlendirme: Tüm çocukların ve ebeveynlerin deneyimlerini birbirleriyle paylaşmaları ve birbirlerinden öğrenmeleri için fırsat verilir.	Gün sonunda tüm çocuklar ve ebeveynlerin dahil olacağı bir tartışma ortamı yaratılır. Her ebeveyn-çocuk grubundaki çocuk sırayla herkesin görebileceği bir yere gelir ve tasarım sürecini diğer gruplarla paylaşır. Sunum yapan çocuk ilk prototipinde kullanmayı planladığı materyallere ve tasarım sürecinin başında ne tür bir tasarım yapmayı planladığına değinerek hem çizdiği planı ve hem de modelini diğer gruplara gösterir. Sunum yapan çocuğun aynı zamanda ilk ve son prototipi arasındaki farklılıklara değinerek tasarımını süreçte nasıl geliştirdiğini açıklaması beklenir. Bu sırada, öğretmen sunum yapan çocuğa çeşitli sorularla rehberlik eder. Öğretmen tarafından bu aşamada sorulabilecek sorular aşağıda örneklendirilmiştir. • *"Sence tasarımın papağanın problemini çözdü mü?"* • *"Bu problemi çözmek için ilk önce ne yaptın?"* • *"Planında neler çizdin?"* • *"Planını çizdikten sonra ne yaptın?"* • *"Modelinde hangi malzemeleri kullanmıştın?" ya* da • *"Modelini havlu kâğıt rulolarıyla (çocuk hangi materyali kullanmışsa) yaptığını hatırlıyorum. Peki bu modelin kaplumbağayı taşıyıp taşıyamadığını denedin mi?* • *"Tasarladığın bu köprüden kimler geçecek?"* • *"Tasarımında neden bu malzemeyi kullandın?"* • *"Neden bu malzemeyi kullanmayı tercih ettin?"* • *"İlk denemende başarılı oldun mu?"* • *"Peki sonra tasarımını geliştirmek için ne yaptın?"* • *"Köprün kaplumbağanın geçebileceği kadar geniş mi?"* • *"Köprün kaplumbağayı taşıyabilecek kadar sağlam mı?"* • *"Eğer biraz daha zamanımız olsaydı, tasarımını geliştirmek ister miydin?"* • *"Bu köprü tasarımı biraz daha geliştirecek olsan başka neler yapardın?"* Tüm gruplar birbirlerinin sunumlarını dinlemek ve bu sayede bir probleme birden çok çözüm üretilebileceğini görmek için teşvik edilir. Çocuklar ayrıca birbirlerinin tasarımlarına yorum yapma, tasarımları daha da geliştirmek için birbirlerine fikir verme konusunda desteklenir. "Sağlam bir köprü yapmanın yolları nelerdir?" sorusuna geri dönülür ve sağlam köprülerin özellikleri listelenir. Farklı türdeki köprüler üzerine tekrar konuşulur, dünyanın çeşitli yerlerinde farklı tasarımlara sahip (kemerli köprü, asma köprü, vb.) köprüler çeşitli görseller aracılığıyla incelenir. Gruplar, hangi şekildeki köprünün, neden diğerlerinden daha sağlam olabileceği üzerine tahminde bulunur, kendi köprülerinin en çok hangisine benzediğini düşünürler. Çocuklar ve ebeveynlerle bir şey inşa etmek, onu test etmek ve onu yeniden inşa etmeye çalışmanın onlara nasıl

	hissettirdiği hakkında konuşulur. Aktivitenin sonunda papağan görünür ve tüm çocuk ve ebeveynlere kendisine yardım ettikleri için teşekkür eder.  Golden Gate Bridge (USA)  Sydney Harbour Bridge (Avustralya)  Ponte Vecchio (İtalya)  Millau Viaduct (Fransa)
Ev-temelli aile katılımı etkinliği	Öğretmen etkinlik sonunda ebeveynlere üzerinde aşağıdaki metnin yazılı olduğu bir not kağıtlarını dağıtır. ***Sayın Velim*** *Bugün çocuğunuzla birlikte birer mühendis gibi düşünüp kaplumbağanın problemine çözümler ürettiniz. Her biriniz kaplumbağanın nehrin karşısına geçebilmesi için köprüler inşa ettiniz. Peki bulunduğumuz şehirde de pek çok tarihi ve modern köprü yok mu? Bugün öğrendiklerimizi pekiştirebilmek için siz de çocuğunuzla birlikte bulunduğumuz şehirdeki köprülerden birinin üzerinden geçebilir, bu sırada bu köprünün ne amaçla kullanıldığı, bu köprüyü hangi alanda çalışan mühendislerin yapmış olabileceği, bu köprünün yapımında hangi malzemelerin kullanılmış olabileceği, bu köprünün kimlerin kullanımı için (araç ve/veya insan ve hayvanlar) yapılmış olabileceği gibi konularda konuşabilirsiniz. Çocuğunuza bu köprünün sağlam görünüp görünmediğini ve neden böyle düşündüğünü sorabilirsiniz. Köprüden geçtiğiniz sırada bir de fotoğraf çeker ve bana e-mail yoluyla gönderirseniz, bir sonraki etkinliğe geldiğinizde çocuğunuz köprüyü sınıfta bizlere tanıtabilir.*

<table>
<tr><td colspan="2">ETKİNLİK 3</td><td rowspan="5"></td></tr>
<tr><td colspan="2">Etkinlik Adı: Misket Taşıyıcısı</td></tr>
<tr><td colspan="2">Odaklanılan Düşünme Becerisi: Esnek Düşünme</td></tr>
<tr><td colspan="2">Çocukların etkinliğe motive edilmesi: Papağan figürlü el kuklası aracılığıyla çocuklara problem durumunu tanıtılır. Çocuklar evine 3 tane misket taşımak isteyen ama yolda gelirken misketleri düşüren papağan için bu durumun bir problem teşkil ettiğini fark ederler. Çocuklar ebeveynlerinin rehberliğinde, oyuncakçıdan aldığı 3 misketle birlikte ağacın yüksek bir dalına asılı olan evine dönmek isteyen papağan için çeşitli sistemler tasarlamanın yollarını keşfederler.</td></tr>
<tr><td colspan="2">Etkinliğin Odağı: Papağan misketleri düşürmeden evine getirebilmek için birçok yol denemiştir. Papağanın anlatacaklarından yola çıkan bu etkinlik okul öncesi dönem çocuklarının esnek düşünme becerilerine ve papağanın problemi çözmeye yönelik girişimlerini gözlemleyip bu probleme yeni öneriler sunmalarına odaklanmaktadır.</td></tr>
<tr><td colspan="3">Kazanım ve göstergeler: K1.1, K1.2, K3.1, K3,2, K4.1, K4.2; S1, S2, S3, S4, S5, S6, S7; D3; F1, F2, F3, F4, F5, F6.</td></tr>
<tr><td>Kavramlar:</td><td colspan="2">Mühendis, mühendislik, plan, model, tasarım, kaldıraç, yük-kuvvet-destek, hareketli-hareketsiz, aşağıda-yukarıda, alçak-yüksek.</td></tr>
<tr><td>Kullanılacak Materyaller:</td><td>• Papağanın ilk etkinlikte kullanılan evi
• Çok sayıda açık uçlu materyal
• Çocukların ve ebeveynlerin fikirlerini not etmek için yazı tahtası ve kalemler
• Çocuklar ve ebeveynlerin tasarımlarının planını yaparken kullanmaları için beyaz çizim kağıtları
• Plastik kaşık, abeslang çubukları ve paket lastiğinden yapılmış basit bir mancınık sistemi (yanda görseli sunulmuştur).
• Her grup için 3'er adet misket
• Fotoğraf makinesi
• Bir adet yün battaniye</td><td></td></tr>
<tr><td colspan="3">Öğrenme Süreci</td></tr>
<tr><td>Problem durumu çocuklara tanıtılır</td><td colspan="2">Etkinliğe başlamadan önce ilk iki atölyede öğrenilenler hatırlanır. Mühendislerin ne iş yaptığı, hangi mühendislik alanları olduğu, mühendislerin tasarımlarının günlük yaşamımızı nasıl etkilediği, çevremizde gördüğümüz objelerden hangilerinin birer teknoloji olabileceği üzerine sohbet edilerek güne başlanır. Önceki haftalarda çocukların ebeveynleri ile birlikte birer mühendis gibi çalışıp hangi problemlere çözümler ürettikleri ve neler tasarladıkları üzerine konuşulur;
• "İlk hafta papağanın bir problemi (sorunu) vardı hatırladınız mı?"
• "Siz küçük mühendisler bu problemi çözmek için ne yapmıştınız?"</td></tr>
</table>

- *"Peki geçen hafta papağanla birlikte birisi daha gelmişti sınıfımıza. Kim olduğunu hatırlayan var mı?"*
- *"Peki kaplumbağanın problemi neydi?"*
- *"Kaplumbağaya nasıl yardım etmiştiniz? Siz küçük mühendisler olarak onun problemini nasıl çözmüştünüz?"*

Evde başka tasarımlar yapıp yapmadıkları sorulur. Yapmışlarsa bu tasarımı hangi problemi çözmek için yaptıklarını anlatmaları istenir. Bir önceki atölyede yapılan köprü tasarımları hatırlanır. Her gruptan hangi köprüyü ziyaret ettikleri ve çekilen fotoğraflar aracılığıyla bu köprünün özellikleri hakkında çok kısa bir sunum yapmaları istenir.

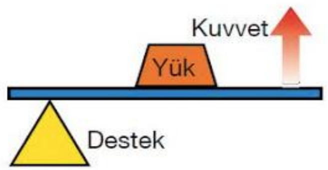
Daha sonra, papağan figürlü el kuklası çocukları ve ebeveynleri selamlar.

> "*Merhaba çocuklar ve onların sevgili anne babaları. Sizi tekrar görmek ne güzel. Bugün nasılsınız?" (Çocukların yanıtlarını dinledikten sonra) Ben bugün biraz üzgünüm. Neden mi? Hemen anlatayım. Bugün öğleden sonra arkadaşım Deniz beni ziyarete gelecekti. Deniz misketlerle oynamaya bayılır. Ben de birlikte oynamak için oyuncakçıdan misket aldım. Fakat misketleri bir türlü evime taşıyamıyorum çünkü evim çok yüksekte. Aslında misketleri evime taşıyabilmek için pek çok yol denedim. Mesela yanıma bir sırt çantası aldım ve misketleri ona koydum sonra da uçmaya başladım."*

Bu sırada öğretmen çocuklara bu yöntemin işe yarayıp yaramayacağını sorar. Çocukların tahminleri alındıktan sonra papağan konuşmaya devam eder;

> *"Maalesef çocuklar, çanta kanatlarım için çok ağır olduğundan eve kadar uçamadım. Daha sonra bir mancınık tasarladım ve misketleri bu mancınıkla evime fırlatmayı denedim."*

Çocukların mancınığın ne olduğunu bilmeme ihtimaline karşın öğretmen çocuklara elindeki mancınığın çalışma sistemini kısaca açıklar. Mancınık sistemi basit bir kaldıraç sistemidir. Bu kaldıraç sisteminde yük ortada, destek noktası aşağıda ve kuvvet noktası en yukarıdadır.



Tüm çocuklar mancınık sistemini mancınıkla ponpon fırlatarak deneyimler. Daha sonra öğretmen "*Ne dersiniz çocuklar sizce papağan mancınık kullanarak misketleri evine gönderebilmiş midir?*" diye sorar. Papağan tarafından gerçekleştirilen her iki girişim için de çocukların cevapları dinlenir ve grafik üzerinde simgelenir. Evet diyen çocuklarla neden evet dedikleri, hayır diyen çocuklarla da neden hayır dedikleri üzerine konuşulur ve çocuklar tarafından sunulan sebepler de grafik üzerine not edilir. Öğretmen;

	“Ne dersiniz birlikte mancınıkla misket fırlatmayı deneyelim mi?” diye sorar. Gerekli güvenlik önlemleri alındıktan sonra tüm çocuklara deneyimleme fırsatı sunulur. Daha sonra papağan tekrar konuşmaya başlar; *“Maalesef çocuklar, siz de gördünüz, mancınıkla fırlattığım misketler sağa sola saçıldı. Hiçbirini evime ulaştıramadım.”*
Çocukların problem-çözme amacını anlamalarına yardım edilir.	Papağanın problemini çözmek için kaç farklı yol denediği çocuklarla birlikte sayılır. Daha sonra çocuklara “*Sizce neden problemi çözmek için birden çok yol denemiş olabilir?*” sorusu yöneltilir ve çocukların yanıtları dinlenir. Çocukların, insanların bir problemle karşılaştıklarında bu problemi çözebilecek bir sonuca ulaşmadan önce birden çok yol denediklerini görmeleri sağlanır. Benzer şekilde, mühendisler de tasarımlarını geliştirmek için pek çok kez deneme yaptıkları söylenir. Daha sonra öğretmen problemin çocuklar tarafından daha net anlaşılmasını sağlamak için sınıfa getirdiği yün battaniyeyi gösterir. Çocuklara bu battaniyeyi kaldırmaya çalışırlar. Öğretmen; *“Çocuklar hepiniz battaniyeyi kaldırmayı denediniz. Peki sizce bu battaniye ağır mı hafif mi? Bu battaniyeyi yukarıdaki dolabın içine koymak istesem zorlanır mıyım? Papağan da misketler ona ağır geldiği için taşımakta zorlanmış. Peki sizce insanlar böyle ağır şeyleri taşımak için ne yapıyor olabilirler? Peki biz papağanın misketlerini yukarıya çıkarmak için neler yapabiliriz?”* Çocukların önerileri dinlenir, uygun bir öneri sunulmazsa ve/veya problem durumunun anlaşılmadığı hissedilirse öğretmen çeşitli sorularla çocukları düşündürmeye devam eder; *“Çocuklar siz daha önce hiçbir evden başka bir eve taşınan birini görmüş müydünüz? O insanlar eşyalarını apartmanların yüksek katlarına nasıl çıkarıyorlar? Peki biz binaların yüksek katlarına nasıl kolayca çıkabiliyoruz?”* Ardından ebeveyn ve çocuklara günün görevi tanıtılır. *“Bugün misketleri papağanın evine taşıyabilmenin yollarını düşüneceğiz. Böylece, eğer bazı fikirlerimiz işe yaramazsa, aklımızda denemek için başka fikirlerimiz olacak. Bugünkü göreviniz misketleri papağanın evine taşıyabilmenin en az iki farklı yolunu göstermek. Bu yüzden sen de düşün, dene, geliştir ve paylaş.”*
Mevcut materyaller keşfedilir ve sınırlılıklar belirlenir.	Çocuklar ve ebeveynlere mühendislerin tasarımları hakkında bir karar verip plan çizme aşamasına geçmeden önce birtakım sınırlılıkları belirledikleri hatırlatılır. Papağanın evi üzerine ağaç resmi yapıştırılmış 50 cm kadar yükseklikte bir yapı üzerine konumlandırılır. İlk sınırlılık tasarlanacak olan sistemin misketleri bu yüksekliğe çıkarabilmesidir. Ebeveynlerinin rehberliğinde, standart veya standart olmayan ölçe araçları sayesinde çocukların bu yüksekliği hesaplamaları sağlanır. Bir diğer sınırlılık ise misketlerin şeklidir. Mekanizma misketlerin yuvarlanıp aşağı düşme ihtimali göz önüne alınarak tasarlanmalıdır. Çocukların daha önce misket görmemiş veya misketle oynanmamış olma ihtimaline karşın tüm gruplara 3’er tane misket verilir ve çocukların misketlerle deneyim kazanmaları sağlanır.

Fikirler planlar ve modeller (prototip) ile temsil edilir.	Çocuklar ve ebeveynlerin misketleri papağanın evine taşıyabilmek için iki farklı plan oluşturmalarına yardımcı olunur. Bu bir çizim, biz taslak, bir diyagram, bir model olabileceği gibi çocukların sözel olarak da ifade edebileceği bir plan olabilir. Ebeveynler çocuklarının planlarıyla ilgili çizim yapmalarına, fikirlerini sözlü olarak dile getirmelerine rehberlik eder, plana dair sözel açıklamalarını not ederler. Çocuklar çizimlerini bitirdiklerinde öğretmen tek tek yanlarına gider ve çocuğun problem durumunu anlayıp anlayamadığını çeşitli sorular aracılığıyla test eder. Örneğin; *“Sen papağanın bir problemini çözmek için düşündün ve bu planı çizdin öyle değil mi? Peki papağanın bu haftaki problemi neymiş?”* *“Papağan bu hafta bizden hangi konuda ona yardım etmemizi istiyor?”* Çocuğun planıyla ilgili detayları anlatmasını sağlamak için sorulabilecek sorular aşağıda örneklendirilmiştir. • “*Nasıl bir sistem yapmayı düşünüyorsun?”* • *“Hangi malzemeleri kullanmayı planlıyorsun?”* • *“Neden bu sistemde ... (çocuğun kullanacağını söylediği materyal) kullanmanın iyi bir fikir olacağını düşündün?”* • *“Bu sistem nasıl çalışacak?”* • *“Seni mezurayla ölçüm yaparken görmüştüm. Papağanın evinin yüksekliği ne kadarmış?”* Çizilen planlar daha sonra süreci gözden geçirmek için kullanılmak üzere saklanır. Öğretmen, ebeveyn ve çocuklara ürettikleri bu fikirlerin problemi çözüp çözmeyeceğini görmeleri için, tıpkı mühendislerin yaptığı gibi, bu fikirleri yansıtan birer model inşa etmelerinin iyi bir fikir olacağını söyler. Daha sonra gerçek bir yapının modelini yapmanın ne anlama geldiği üzerine tekrar konuşulur. Öğretmen, ebeveyn ve çocuklara ürettikleri bu fikirlerin problemi çözüp çözmeyeceğini görmeleri için, tıpkı mühendislerin yaptığı gibi, bu fikirleri yansıtan birer model inşa etmelerinin iyi bir fikir olacağını hatırlatır. Daha sonra gerçek bir yapının modelini yapmanın ne anlama geldiği üzerine tekrar konuşulur. Her grup kendi ürettiği en az iki fikirden istediği herhangi birini model aracılığıyla temsil eder. Modeller üzerinde kaldıraç (kuvvet-yük-destek) sistemi hakkında konuşulur. Oluşturduğu modeli deneyen çocuk bu sayede tasarımında hangi materyali kullanacağına ve tasarımının nasıl görüneceğine dair daha net bir fikir geliştirebilir. Çocukların plan ya da taslaklarına ait çizimler ya da yazılı ifadeler, modellerinin deneme öncesi ve sonrası çekilmiş fotoğrafları, modelin geliştirildikten sonraki halini gösteren fotoğrafları ve tasarımın ilk ve son hallerinin fotoğrafları her grubun kendi mühendislik defterine eklenir.

Modeller test edilir.	Çocuklar ve ebeveynleri inşa ettikleri modelleri tamamlamış göründüklerinde sistemlerini test etmelerine yardımcı olunur ve yapılarının testi geçip geçemediğini, geçemediyse neden geçememiş olabileceği, geçtiyse neden geçmiş olabileceği değerlendirilir. Öğretmen çocuklara "*Modelini yaptığınız sistemlerin papağanın problemini çözüp çözemeyeceğini merak ediyorum*" der ve "*Test etmek için bir yol bulmalıyız. Nasıl test edebileceğimiz konusunda ne düşünüyorsunuz?*" diye sorar. Çocuklara modellerini test etmek için bir yol bulmalarında yardımcı olunur. Aşağıdaki öneriler sunulabilir; • *"Sistem misketleri papağanın evine taşımaya yetecek kadar uzun mu? Sistemde kullanılan taşıyıcı üç misketin de sığabileceği kadar geniş mi?"* • *"Sistem üç misketi de düşürmeden papağanın evine taşımayı sağlayacak kadar sağlam mı?"* Test etme aşamasında öğretmen çocuklar ve ebeveynlerini tekrar tekrar denemeye teşvik etmelidir. Öğretmen çocuklara, gerçek mühendislerin de modeller üzerinde çalıştıklarını, bu modelleri sürekleri test ettiklerini ve bu denemeler sonucunda tasarımlarını geliştirdikleri hatırlatılır. Gruplar modellerini test ederler. Bu sonucun birazdan yapacakları tasarım için ne anlama geldiği sorulur. • *"O zaman tasarımını yaparken nasıl yapacaksın?" ya da* • *"Modelinde bu malzemeyi kullanmıştın ve modelini test ettin. Peki ne oldu? Modelin testi geçebildi mi?* • *"Peki o zaman tasarımında hangi malzemeyi kullanmayı düşünüyorsun?"* Karşılaşabilecekleri olası bir başarısızlık durumunda yeni çözümler üretmeleri için teşvik edilirler. Modellerini sınırlılıklar açısından test eden çocuklar ve ebeveynler bu deneyimlerinin olumlu veya olumsuz sonuçları doğrultusunda modellerini geliştirme yoluna giderler. Bir grubun tasarımı ilk denemede testi geçerse bu grup aynı problem için ürettiği ikinci çözüm yolunu denemeye teşvik edilir.
Tasarımlar inşa edilir.	Modeller test edildikten sonra, her grubun kafasında gerçek tasarımlarında hangi materyalleri kullanacaklarının netleşmesi beklenmektedir. Bunun yanı sıra, çocuklar modeller üzerinde yaptıkları çeşitli deneme yanılmalar sonucunda gerçek tasarımlarının nasıl görüneceği ve nasıl bir sistem oluşturmaları gerektiği hakkında daha net fikirlere sahip olacaktır. Modeller üzerinde yapılan deneme yanılmalar doğrultusunda her grup tasarımında kullanacağı malzemeleri seçer ve kendi tasarımını inşa etmeye başlar.

Tasarımlar denenir.	Her grup kendi tasarımının problemi çözüp çözmeyeceğini dener. Çocukların ve ebeveynlerinin denemeler sırasında ne olduğunu tanımlamalarına çeşitli sorular aracılığıyla yardımcı olunur. Örneğin; • *"Ne oldu?"* • *"Ne fark ettin"* • *"Tekrar denemek ister misin?"* Ne olduğu tanımlandıktan sonra bunun neden olduğu yönündeki fikirleri alınır. Örneğin; • *"Sence misketler neden aşağıya yuvarlandı?"* • *"Sence misketler neden yuvaya kadar çıkamadı?"* • *"Sence tasarımının başarılı olmasını sağlayan neydi?"* • *"Bu sistemle başka neleri yukarıya taşıyabiliriz?"* • *"Bu sistemi nereden ilham alarak tasarladınız?"*
Tasarımlar denemeler sonrasında geliştirilerek tekrar denenir.	Her grup tasarımlarını test edip sonuçları gördükten sonra, tasarımları üzerine tekrar düşünür ve tasarımlarını geliştirir. Etkinlik süresince çocuklar ve ebeveynlere tasarladıkları sistemleri geliştirmeleri, üç adet misketle denedikten sonra farklı materyallerle de (örneğin; ponpon, çakıl taşları, pamuk, top haline getirilmiş kâğıt vs.) tekrar tekrar denemeleri için fırsat verilir.

Değerlendirme: Tüm çocukların ve ebeveynlerin deneyimlerini birbirleriyle paylaşmaları ve birbirlerinden öğrenmeleri için fırsat verilir.	Gün sonunda tüm çocuklar ve ebeveynlerin dahil olacağı bir tartışma ortamı yaratılır. Her ebeveyn-çocuk grubundaki çocuk sırayla herkesin görebileceği bir yere gelir ve tasarım sürecini diğer gruplarla paylaşır. Sunum yapan çocuk ilk prototipinde kullanmayı planladığı materyallere ve tasarım sürecinin başında ne tür bir tasarım yapmayı planladığına değinerek hem çizdiği planı ve hem de modelini diğer gruplara gösterir. Sunum yapan çocuğun aynı zamanda ilk ve son prototipi arasındaki farklılıklara değinerek tasarımını süreçte nasıl geliştirdiğini açıklaması beklenir. Bu sırada, öğretmen sunum yapan çocuğa çeşitli sorularla rehberlik eder. Öğretmen tarafından bu aşamada sorulabilecek sorular aşağıda örneklendirilmiştir. • *“Planında iki tane çözüm yolu çizmiştin. Bunları bize gösterir misin?”* • *“Modelinde hangi malzemeyi/ malzemeleri kullanmıştın?”* • *“Neden modelinde bu malzemeyi kullanmayı tercih etmiştin?”* • *“Modelini denedin değil mi? Peki ne oldu? Ne fark ettin?”* • *“Tasarımında hangi malzemeyi/malzemeleri kullandın?”* • *“Görüyorum ki ipler ve makaralardan oluşan bir yapı tasarlamışsınız.”* • *“Neden tasarımında bu malzemeyi kullanmayı tercih ettin?”* • *“Bu sistemin nasıl çalışacağını açıklayabilir misin?”* • *“Tasarımını denedin mi? Peki denerken neler oldu?” Birlikte de deneyelim mi?”* • *“Sence tasarımın papağanın problemini çözdü mü?”* • *“Tasarımını geliştirmek için başka neler yapmayı düşünüyorsun?”* Tüm grupların birbirlerinin sistemlerinin planlarını, nasıl çalıştığını görmeleri sağlanır. Her grubun diğer grupların fikirlerin, değerlendirmelerine rehberlik edilir. “*Bu tasarım hakkında ne düşünüyorsun? Sence işe yarayacak mı?*” gibi. Gruplar birbirlerinin tasarımlarıyla ilgili detaylı sorular sormaları konusunda desteklenir. Öğretmen gibi bir takım teşvik edici sorular sorabilir. Tüm gruplar tasarımlarını paylaştıktan sonra, “*Misketleri yukarıya taşıyabilmek için üretilen fikirlerden hoşunuza giden hangileriydi? Neden bu fikir hoşunuza gitti?*” sorusu sorulur. Tüm fikirler not edilir. Son olarak toplam kaç fikir üretildiği sayılır ve problem çözmek için birden çok fikir üretmenin neden yararlı olabileceği üzerine tartışılır. Aktivitenin sonunda papağan görünür ve tüm çocuk ve ebeveynlere kendisine yardım ettikleri için teşekkür eder.
Ev-temelli aile katılımı etkinliği	Bu etkinlikte öğrenilenler çocukların kuvvet-yük-destek kavramlarını evde de deneyimleyebilmelerini sağlayacak bir ev-temelli katılım etkinliği ile pekiştirilebilir. Bunun için ebeveynler evde çocukları ile birlikte bir mancınık inşa edebilir. Mancınığın yapımında aşağıda linki verilen yönerge ve bu yönergede yer alan malzemeler kullanılabilir. Ebeveynler çocuklarını farklı ağırlıklardaki çeşitli materyalleri (kâğıt, taş, pinpon topu, ponpon vs.) mancınık aracılığıyla fırlatmak için teşvik edebilirler. Bu sırada mancınık üzerinden kuvvet-yük-destek sistemi ile ilgili sohbet edilebilir. Çocuğun aynı kuvvet uygulandığında kâğıdın ve misketin farklı mesafelere fırladığını deneyimlemeleri ve bu durumun nedeni hakkında düşünmesi sağlanır. http://www.bilimgenc.tubitak.gov.tr/makale/mancinik-yapalim

ETKİNLİK 4

Etkinlik Adı: Yeşil Nehir Temiz Kalsın

Odaklanılan Düşünme Becerisi: Yansıtıcı Düşünme

Çocukların etkinliğe motive edilmesi: Papağan figürlü el kuklası aracılığıyla çocuklara problem durumunu tanıtılır. Çocuklar nehirdeki kirlilikten dolayı suda yaşayan bazı canlıların olumsuz etkilendiğini ve bu durumun hayvanlar için bir problem teşkil ettiğini fark ederler. Çocuklar ebeveynlerinin rehberliğinde, su kirliliğini önlemek için farklı sistemler tasarlamanın yollarını keşfederler.

Etkinliğin Odağı: Papağanın anlatacaklarından yola çıkan bu etkinlik okul öncesi dönem çocuklarının mühendislik deneyimlerinin dokümantasyonuna ve neyin iyi çalıştığı neyin iyi çalışmadığı konusunda çocukların düşünmelerinin desteklenmesine odaklanmaktadır.

Kazanım ve göstergeler: K3.1, K3,2, K4.1, K4.2, K5.1, K5.2; S1, S2, S3, S4, S5, S6, S7; D4; F1, F2, F3, F4, F5, F6.

Kavramlar:	Mühendis, tasarım, atık, çevre, geri dönüşüm, bakteri, kirlilik, arıtma, filtre.
Kullanılacak Materyaller:	• Kaplumbağa figürlü bir el kuklası • Çok sayıda açık uçlu materyal • Çocukların ve ebeveynlerin fikirlerini not etmek için yazı tahtası ve kalemler • Çocuklar ve ebeveynlerin tasarımlarının planını yaparken kullanmaları için çizim kağıtları • Hava, su ve toprak kirliliğine yönelik görseller • İçi su dolu derin ve geniş bir plastik kap. • Fotoğraf makinesi
Öğrenme Süreci	
Problem durumu çocuklara tanıtılır	Etkinlik çocukların sınıfa geldiklerinde sınıf ortamının çeşitli atıklarla dolu olduğunu fark etmeleri ile başlar. Atıkların çocukların sağlık ve güvenliği için tehdit oluşturmayacak türden (kullanılmış ambalaj kağıtları, piller, kullanılıp atılmış pet şişeler, kâğıt parçaları…) olmasına dikkat edilmelidir. Çocuklara sınıf ortamında dikkatlerini çeken bir şey olup olmadığı sorulur. Çocukların cevapları alındıktan sonra bu sınıf ortamının nasıl göründüğü ve sınıftaki bu kirliliğin bu ortamı kullanan insanlar için zararlı olup olmayacağı sorulur. Daha sonra tüm çocuklar eldivenlerini takar ve hep birlikte sınıf ortamını bu atıklardan temizler. Sınıfın temizlik bittikten sonra nasıl göründüğü, nasıl koktuğu, bu ortamı kullanan insanlar için sağlık açısından tehlike taşıyıp taşımadığı üzerine konuşulur.

	Daha sonra, çocuklar sınıfın köşesinden gelen bir ağlama sesi duyarlar (öğretmen seslendirir). Bu sesin kimden geliyor olabileceği sorulur. Kaplumbağa görünür, çok üzgün olduğunu ve bu hafta çok önemli bir şey için çocuklardan yardım istediğini söyler. Çocuklardan kaplumbağanın neden üzgün ve ağlıyor olabileceği sorulur. Geldiği kasabada çok güzel bir nehir olduğunu, bu nehrin adının "Yeşil Nehir" olduğunu ve bu nehirde pek çok hayvanın yaşadığını söyler. Öğretmen çocuklara "*Sizce yeşil nehirde hangi canlılar yaşıyor olabilir?*" diye sorar. Çocukların cevapları alındıktan sonra sözü tekrar kaplumbağa alır ve çeşitli atıklar yüzünden yeşil nehrin kirlendiğini ve bu yüzden bazı hayvanların zehirlendiğini anlatır. Çocuklardan kendisine yardım etmelerini ister. Çocuklar ve aileleri tasarım sürecine başlamadan önce, çocukların dikkati çevre problemlerine çekilir. İlk olarak "atık" sözcüğünü daha önce duyup duymadıkları, duymuşlarsa örneklendirmeleri istenir. Çevremize bıraktığımız, attığımız veya bazı faaliyetler sonucunda oluşan her çeşit maddeye atık dendiği (Çevre Kanunu, 1983) açıklanır. Suyun, toprağın ve havanın insanlar, hayvanlar, bitkiler ve tüm diğer canlılar için önemi hakkında konuşulur. Çeşitli atıkların suyu, havayı, toprağı nasıl kirletebileceği ve bu kirliliğin sebep olabileceği sonuçlar üzerine konuşulur. Örneğin havadaki kirlilikten dolayı bazı bitkiler kuruyabilir. Havada, suda ve topraktaki kirlilikten dolayı insanlar ve hayvanlar hastalanabilir. Son olarak suda, havada ve toprakta çeşitli atıklardan dolayı meydana gelen kirliliği nasıl önleyebileceğimiz üzerine konuşulur. Çevrede meydana gelen bu problemleri çözmek için çeşitli tasarımlar yapan mühendislere çevre mühendisi dendiği söylenir (Cunningham, 2009). Filtrenin ne olduğu hakkında konuşulur. Çeşitli filtrelere ve kullanım alanlarına örnekler verilir. Örneğin öğretmen bir demlik ve çay süzgeci aracılığıyla evlerimizdeki çay süzgeçlerinin çay tanelerini filtrelediğini gösterebilir. Çocukların veya ebeveynlerin de örnek vermeleri istenir. Daha sonra her gruba içerisinde Yeşil Nehirdeki ile aynı tür atıkların bulunduğu orta büyüklükte içi su dolu leğenler verilir. Çocuklara bu suların temiz mi kirli mi olduğu sorulur. Alınan cevaplara göre suyun neden kirli olduğu tartışılır. Çocuklara çeşitli atıkların nehirdeki suyu kirlettiği söylenir. Çocuklara bu suyun filtrelenerek temizleyip temizlenemeyeceği sorulur. Daha sonra öğretmen; *"Ne dersiniz çocuklar, biz de birer çevre mühendisi gibi çalışıp yeşil nehrin temizlenmesine yardım edelim mi?"*
Çocukların problem-çözme amacını anlamalarına yardım edilir.	Çocuklara mühendislerin problemleri çözmeye çalışırken neler yaptıklarını kendilerine ve başka insanlara hatırlatması için yazdıkları hatırlatılır. Mühendislerin bu yüzden not defterlerini kullandıkları hatırlatılır. Öğretmen günün aktivitesini çocuklara ve ebeveynlere tanıtır. *"Biz de bugün bir çevre mühendisi gibi çalışacak, Yeşil Nehri temizlemenin yollarını düşüneceğiz. Yeşil Nehirde çeşitli atıklar (plastik bardak, pet şişe, pil, poşet, sakız vb.) bulunmakta. Bu atıkların üzerinde bakteriler olduğu için insanlar onlara dokunmamalılar. Bu yüzden sizin yeşil nehri plastik atıklardan temizleyip filtreleyebilecek bir tasarım yapmalısınız. Tasarımlarınızı denemeden önce ve denedikten sonra fotoğraflarını çekeceğiz. Bu fotoğraflarla mühendislik defterlerimizi oluşturacağız. Böylece, yaptığımız hiçbir şeyi unutmayacak ve tasarımlarımızı daha da geliştireceğiz."*

Mevcut materyaller keşfedilir ve sınırlılıklar belirlenir.	Çocuklar ve ebeveynlere, mühendislerin tasarımları hakkında bir karar verip model oluşturma aşamasına geçmeden önce birtakım sınırlılıkları göz önünde bulundurdukları hatırlatılır. İlk sınırlılık suda kirlilik oluşturan atıklara temas edilmeden, tasarlanacak bir sistem aracılığıyla temizlenmesi gerektiğidir. Bir diğer sınırlılık, bu sistemin suyu hem plastik bardak ve sakız gibi daha büyük boyutlu atıklardan hem de daha küçük boyutlu atıklardan temizlemesi gerektiğidir. Son sınırlılık ise para, zaman ve enerji tasarrufu yapabilmek adına suyun temizlenmesi ve filtrelenmesi işini tek bir tasarım aracılığıyla yapmaları gerektiğidir. Öyle ki, yapacakları tasarım suyu hem büyük boyutlu hem de çok daha küçük boyutlu (kum taneleri gibi) nesnelerden temizleyebilecek şekilde olmalıdır. Bunun için çocukların mevcut materyalleri ve incelemeleri ve deneyim kazanmaları sağlanır.
Fikirler planlar ve modeller (prototip) ile temsil edilir.	Çocuklar ve ebeveynlerin nehri temizlemeye yarayacak olan tasarımları için plan oluşturmalarına yardımcı olunur. Bu bir çizim, biz taslak, bir diyagram, bir model olabileceği gibi çocukların sözel olarak da ifade edebileceği bir plan olabilir. Ebeveynler çocuklarının planlarıyla ilgili çizim yapmalarına, fikirlerini sözlü olarak dile getirmelerine rehberlik eder, plana dair sözel açıklamalarını not ederler. Çocuklar çizimlerini bitirdiklerinde öğretmen tek tek yanlarına gider ve çocuğun problem durumunu anlayıp anlayamadığını çeşitli sorular aracılığıyla test eder. Örneğin; *“Sen papağanın bir problemini çözmek için düşündün ve bu planı çizdin öyle değil mi? Peki papağanın bu haftaki problemi neymiş?”* *“Papağan bu hafta bizden hangi konuda ona yardım etmemizi istiyor?”* Çocuğun planıyla ilgili detayları anlatmasını sağlamak için sorulabilecek sorular aşağıda örneklendirilmiştir. • “*Nasıl bir filtre yapmayı düşünüyorsun?”* • *“Hangi malzemeleri kullanmayı planlıyorsun?”* • *“Neden bu filtreyi yaparken ... (çocuğun kullanacağını söylediği materyal) kullanmanın iyi bir fikir olacağını düşündün?”* Çizilen planlar daha sonra süreci gözden geçirmek için kullanılmak üzere saklanır. Öğretmen, ebeveyn ve çocuklara ürettikleri bu fikirlerin problemi çözüp çözmeyeceğini görmeleri için, tıpkı mühendislerin yaptığı gibi, bu fikirleri yansıtan birer model inşa etmelerinin iyi bir fikir olacağını hatırlatır. Daha sonra gerçek bir yapının modelini yapmanın ne anlama geldiği üzerine tekrar konuşulur. Her grup kendi tasarım fikrini geliştirdiği model aracılığıyla temsil eder. Modeller üzerinde filtreleme sistemi hakkında konuşulur.

Modeller test edilir.	Çocuklar ve ebeveynleri inşa ettikleri modelleri tamamlamış göründüklerinde sistemlerini test etmelerine yardımcı olunur ve yapılarının testi geçip geçemediğini, geçemediyse neden geçememiş olabileceği, geçtiyse neden geçmiş olabileceği değerlendirilir. Öğretmen çocuklara "Modelini yaptığınız sitemin Yeşil Nehirdeki çevre problemini çözüp çözemeyeceğini merak ediyorum." der ve "Test etmek için bir yol bulmalıyız. Nasıl test edebileceğimiz konusunda ne düşünüyorsunuz?" diye sorar. Çocuklara modellerini test etmek için bir yol bulmalarında yardımcı olunur. Aşağıdaki öneriler sunulabilir; • Tasarlanan filtre sisteminde yer alan süzgeç delikleri kalemtıraş artıkları gibi küçük parçalı atıkları da filtreleyebilecek boyutlarda mı? • Tasarlanan filtre suya temas ettirildiğinde zarar görmeyecek materyallerle (suya dayanıklı) mi yapılmış? Test etme aşamasında öğretmen çocuklar ve ebeveynlerini tekrar tekrar denemeye teşvik etmelidir. Öğretmen çocuklara, gerçek mühendislerin de modeller üzerinde çalıştıklarını, bu modelleri sürekleri test ettiklerini ve bu denemeler sonucunda tasarımlarını geliştirdikleri hatırlatır. Gruplar modellerini test ederken karşılaşabilecekleri olası bir başarısızlık durumunda yeni çözümler üretmeleri için teşvik edilirler. Modellerini sınırlılıklar açısından test eden çocuklar ve ebeveynler bu deneyimlerinin olumlu veya olumsuz sonuçları doğrultusunda modellerini geliştirme yoluna giderler.
Tasarımlar inşa edilir.	Modeller test edildikten sonra, her grubun kafasında gerçek tasarımlarında hangi materyalleri kullanacaklarının netleşmesi beklenmektedir. Bunun yanı sıra, çocuklar modeller üzerinde yaptıkları çeşitli deneme yanılmalar sonucunda gerçek tasarımlarının nasıl görüneceği ve nasıl bir sistem oluşturmaları gerektiği hakkında daha net fikirlere sahip olacaktır. Modeller üzerinde yapılan deneme yanılmalar doğrultusunda her grup tasarımında kullanacağı malzemeleri seçer ve kendi tasarımını inşa etmeye başlar.
Tasarımlar denenir.	Her grup kendi tasarımının problemi çözüp çözmeyeceğini dener. Bu sırada öğretmen her grubun tasarımını test etme sürecini tek tek her grubu dolaşarak gözlemler ve tekrar denemek konusunda ısrarcı olmalarını teşvik eder. Çocukların ve ebeveynlerinin ne olduğunu tanımlamalarına çeşitli sorular aracılığıyla yardımcı olunur. Örneğin; • "Ne oldu?" • "Ne fark ettin" • "Tekrar denemek ister misin?" Ne olduğu tanımlandıktan sonra bunun neden olduğu yönündeki fikirleri alınır. Örneğin; • *"Tasarımının tüm artıkları toplayamamasının sebebi sence ne?"* • *"Sence senin filtren suya girince neden bozuldu/bozulmadı?"* • *"Neden tasarımında tuvalet kâğıdı rulolarını kullandınız?"* • *"Sence tasarımının başarılı olmasını sağlayan neydi?"* • *"Bu aletle başka neleri filtreleyebiliriz?"* • *"Bu sistemi nereden ilham alarak tasarladınız?"*

Tasarımlar denemeler sonrasında geliştirilerek tekrar denenir.	Çocuklar ve ebeveynlerine gerçek yapılarının ilk halini test ettikten sonra tekrar deneyebilecekleri, bu yapıları bir şekilde yeniden inşa edip tekrar test edebilecekleri anlatılır. Her grup tasarımlarını test edip sonuçları gördükten sonra, tasarımları üzerine tekrar düşünür ve tasarımlarını geliştirir. Tüm test etme süreçlerinin öncesinde ve sonrasında inşa edilen yapılar mühendislik defterlerine eklenmek üzere fotoğraflanır. Tasarımı başarıya ulaşan çocuklar isteğe bağlı olarak tasarladıkları filtrelerin en fazla ne kadar büyüklük ve küçüklükteki atıkları filtreleyebileceğini test edebilirler.
Değerlendirme: Tüm çocukların ve ebeveynlerin deneyimlerini birbirleriyle paylaşmaları ve birbirlerinden öğrenmeleri için fırsat verilir.	Gün sonunda tüm gruplar sırasıyla diğerlerinin görebileceği bir konuma gelerek tasarımlarının ilk taslaklarını/çizimlerini gösterir ve tasarımlarının tanıtır. Gruplar tasarımlarının ilk halinde hangi malzemeleri kullandığını, neden bu malzemeyi seçtiğini, ilk denemesinde neler olup bittiğini, tasarımını geliştirmek için neler yaptığını ve tasarımının son halini diğer gruplara sunar. Bu sırada öğretmen çeşitli sorularla sunumlara rehberlik eder. Örneğin; *"Planında nasıl bir çözüm yolu çizmiştin. Bize de gösterir misin?"* *"Modelinde hangi malzemeyi/ malzemeleri kullanmıştın?"* *"Neden modelinde bu malzemeyi kullanmayı tercih etmiştin?"* *"Modelini denedin değil mi? Peki ne oldu? Ne fark ettin?"* *"Tasarımında hangi malzemeyi/malzemeleri kullandın?"* *"Neden tasarımında bu malzemeyi kullanmayı tercih ettin?"* *"Bu sistemin nasıl çalışacağını açıklayabilir misin?"* *"Tasarımını denedin mi? Peki denerken neler oldu?" Birlikte de deneyelim mi?"* *"Sence tasarımın Yeşil Nehirdeki kirlilik problemini çözdü mü?"* *"Tasarımını geliştirmek için başka neler yapmayı düşünüyorsun?"* Tüm grupların birbirlerinin sistemlerinin planlarını, nasıl çalıştığını görmeleri sağlanır. Her grubun diğer grupların fikirlerin, değerlendirmelerine rehberlik edilir. "*Bu tasarım hakkında ne düşünüyorsun? Sence işe yarayacak mı?*" gibi. Gruplar birbirlerinin tasarımlarıyla ilgili detaylı sorular sormaları konusunda desteklenir. Tüm gruplar tasarımlarını paylaştıktan sonra, "*Yeşil Nehirdeki kirliliği önlemek için üretilen fikirlerden hoşunuza giden hangileriydi? Neden bu fikir hoşunuza gitti?*" sorusu sorulur. Tüm fikirler not edilir. Aktivitenin sonunda papağan görünür ve tüm çocuk ve ebeveynlere kendisine yardım ettikleri için teşekkür eder.
Ev-temelli aile katılımı etkinliği	Bu etkinlikte geçen atık ve çöp kavramlarının arasındaki farkın çocuk tarafından daha net şekilde anlaşılması ve çevre kirliliğine yönelik farkındalığın pekiştirilmesi amacıyla ebeveynler okul dışı ortamlarda da çocuğunu destekleyebilir. Örneğin, ebeveyn ve çocuklar mühendislik tasarım sürecinin adımlarını izleyerek, evlerinde mevcut olan açık uçlu materyalleri kullanarak evde bir geri dönüşüm kutusu tasarlayabilirler. Bu geri dönüşüm kutusunun bir veya birden çok fonksiyonu ve/veya özelliği olabilir (örneğin; evlerimizdeki çöp kutuları gibi pedallı olabilir, ya da tek bir kutuda farklı türde atıkların toplanabilmesi için farklı bölmeler yer alabilir). Bir aylık bir süre boyunca çocuk ve ebeveynler atıkları bu geri dönüşüm kutusu içerisinde toplayabilirler. Bir aylık süre sonunda ebeveyn ve çocuk bu atıkların nereye gittiğini ve geri dönüşüm sürecinin görebilmek adına şehirde bulunan geri dönüşüm merkezine gezi düzenleyebilir. Unutmayalım ki çocukta bir alışkanlık geliştirmek istiyorsak öncelikle biz yetişkinler o alışkanlık için çocuğa rol model olmalıyız. Dolayısıyla ebeveynlerin de bu süreçte çocuğa atıkların ve çöplerin ayrı kutulara koyulması konusunda bilinçli davranarak model olması gerekmektedir.

Etkinlik 5

Etkinlik Adı: Papağanın Yolda Kalmasın

Odaklanılan Düşünme Becerisi: İşbirlikçi Düşünme

Çocukların etkinliğe motive edilmesi: Bu etkinlikte basit bir zincirleme reaksiyon sistemi yaratılacaktır. Papağan figürlü el kuklası aracılığıyla çocuklara problem durumunu tanıtılır. Papağan çok sevdiği arkadaşı Deniz'in doğum gününe gitmek istemektedir. Fakat arabası bozulmuş ve yolda kalmıştır. Arabasını tamirciye kadar götürmesi gerekmektedir. Çocuklar ebeveynlerinin rehberliğinde, papağanın arabasını tamirciye kadar götürebilecek ve elindeki misketle harekete geçirebileceği bir zincirleme reaksiyon sistemi tasarlamanın yollarını keşfederler.

Etkinliğin Odağı: Papağan çocuklardan arabasını tamirciye kadar götürmesini sağlayacak bir sistem tasarlamakta kendisine yardım etmelerini istemiştir. Papağanının probleminden yola çıkan bu etkinlikte, bu kez gruplar 2'şer çocuk ve bu çocukların ebeveynlerinden oluşmaktadır. Bu nedenle, bu etkinlik okul öncesi dönem çocuklarının hem kendi ebeveynleri ile birlikte işbirliği halinde çalışmalarına hem de başka bir ebeveyn-çocuk grubu ile işbirliği yaparak ortaya aynı amaca hizmet eden ortak bir ürün çıkarmak için kendi çabalarıyla farklı sistemler tasarlamalarına odaklanmaktadır.

Kazanım ve göstergeler: K3.1, K3,2, K4.1, K4.2, K5.1, K5.2; S1, S2, S3, S4, S5, S6, S7; D2; F1, F2, F3, F4, F5, F6.

Kavramlar:	Mühendis, tasarım, model, hareketli-hareketsiz, alçak-yüksek, parça-bütün, eğim, hız, yükseklik.
Kullanılacak Materyaller:	• Çeşitli malzemelerden (kartondan, plastik gibi) yapılmış silindir rulolar (havlu kağıt rulosu, alüminyum folyo rulosu, plastik borular) • Çok sayıda pet şişe • Çeşitli boyut ve şekillerde ahşap bloklar • Grup sayısı kadar büyük boyutlarda misket • Tamirciyi temsil eden bir yapı modeli • Papağanın evi • İçine papağanın sığabileceği ebatlarda bir oyuncak araba • Çocukların ve ebeveynlerin fikirlerini not etmek için yazı tahtası ve kalemler • Çocuklar ve ebeveynlerin tasarımlarının planını yaparken kullanmaları için çizim kağıtları • Fotoğraf makinesi

Öğrenme Süreci	
Problem durumu çocuklara tanıtılır	Etkinliğe başlamadan önce daha önceki haftalarda öğrenilenler hatırlanır. Mühendislerin ne iş yaptığı, hangi mühendislik alanları olduğu, mühendislerin tasarımlarının günlük yaşamımızı nasıl etkilediği, çevremizde gördüğümüz objelerden hangilerinin birer teknoloji olabileceği üzerine sohbet edilerek güne başlanır. Her grup kendi mühendislik defterini inceler ve önceki haftalarda birer mühendis gibi çalışıp hangi sorunlara çözümler ürettikleri ve neler tasarladıkları üzerine konuşulur. Evde başka tasarımlar yapıp yapmadıkları sorulur. Yapmışlarsa bu tasarımı hangi problemi çözmek için yaptıklarını anlatmaları istenir. • *"İlk hafta papağanın bir problemi (sorunu) vardı hatırladınız mı?"* • *"Siz küçük mühendisler bu problemi çözmek için ne yapmıştınız?"* • *"Peki sonraki hafta papağanla birlikte birisi daha gelmişti sınıfımıza. Kim olduğunu hatırlayan var mı?"* • *"Peki kaplumbağanın problemi neydi?"* • *"Kaplumbağaya nasıl yardım etmiştiniz? Sizler küçük mühendisler olarak onun problemini nasıl çözmüştünüz?"* • *"Peki ya geçen hafta kime yardım etmiştik? Papağanın hangi problemine çözüm bulmuştuk?* • *"Bu problemi çözmek için ne tasarlamıştık?"* Daha sonra, papağan figürlü el kuklası çocukları ve ebeveynleri selamlar; *"Merhaba çocuklar ve onların sevgili anne babaları. Sizi tekrar görmek ne güzel. Bugün nasılsınız?". Papağan çocukların yanıtlarını dinledikten sonra, "Ben bugün biraz heyecanlıyım. Neden mi? Hemen anlatayım. Bugün arkadaşım Deniz'in doğum günü. Onun için güzel bir hediye almayı düşündüm ama sonra en güzel hediyenin satın alınan değil düşünüp emek verilen bir şey olması gerektiğine karar verdim ve onun için mis kokulu bir kek yapıp işte bu tatlı hediye paketine koydum. Fakat başıma neler geldi bir bilseniz. Tam hediye paketimi aldım ve doğum gününe gitmek için yola çıkacaktım ki bir de baktım arabam çalışmıyor. Tamir etmeye çalıştım ama başaramadım. Aslında buraya çok yakında bir tamir dükkanı var. Ama arabam hiç çalışmadığından onu oraya ulaştırmam mümkün değil. Siz bana yine yardım edebilirsiniz diye düşündüm. Geçen gün televizyonda görmüştüm. Çocuklar misketi bir yerden bırakıyorlar ve o misket önündeki bazı nesnelere kuvvet uygulayıp onları harekete geçiriyor. Hani siz de geçen hafta birbirinize ellerinizle kuvvet uygulamıştınız ve birbirinizin hareket etmesini sağlamıştınız ya. Benim de yanımda sadece işte bu büyük misket var. Ne dersiniz, birlikte çalışarak biz de bu misketle harekete geçirebileceğimiz bir sistem tasarlayıp arabamı tamirciye kadar götürebilir miyiz?"* Çocuklara bir tasarımın yapımında pek çok mühendisin işbirliği yaptığı anlatılır. Örneğin lunaparktaki atlıkarıncaların makine kısmı için makine mühendisleri, elektrikli kısımları içinse elektrik elektronik mühendisleri çalışır. Benzer şekilde, akıllı telefonların yapımında bilgisayar mühendisleri, elektrik mühendisleri ve makine mühendisleri birlikte çalışır. Bu etkinlikte de her çocuğun başka bir mühendis çocukla ve onun ebeveyni ile işbirliği yapacağı söylenir. Her ebeveyn-çocuk grubu bir başka ebeveyn-çocuk grubu ile eşleşir.

Çocukların problem-çözme amacını anlamalarına yardım edilir.	*Zincirleme reaksiyonun ne olduğunu daha somut şekilde anlatabilmek için izletilecek bir video aracılığıyla örneklenir* (https://www.youtube.com/watch?v=1pl8XqIxgg4). *"Bugün biz de işbirliği yapıp papağanın arabasını tamirciye kadar götürmesine yardım edeceğiz. Bu yüzden sen de düşün, dene, geliştir ve paylaş."*
Mevcut materyaller keşfedilir ve sınırlılıklar belirlenir.	Çocuklar ve ebeveynlere mühendislerin tasarımları hakkında bir karar verip model oluşturma aşamasına geçmeden önce birtakım sınırlılıkları belirledikleri hatırlatılır. Bu tasarım için ilk sınırlılık tasarlanacak olan sistemlerin kuş yuvası ile tamir dükkanı arasında kalmış olan arabayı tamir dükkanına kadar hareket ettirmesi gerektiğidir. Bu sırada gruplar arabaya hiç dokunmadan ve yalnızca tasarladıkları sistem aracılığıyla onu hareket ettirmelidir. Bir diğer sınırlılık ise bu etkinliğin bant, makas, yapıştırıcı gibi temel malzemelerin dışında yalnızca pet şişeler, ahşap bloklar (kapla) ve kartondan veya plastikten yapılmış silindir rulolar (havlu kağıt rulosu, alüminyum folyo rulosu veya plastik borular) ile yapılacak olmasıdır. Son sınırlılık ise bu etkinlikte her bir grubun iki çocuk ve bu iki çocuğun ebeveynlerinden oluşacak olmasıdır. Her bir grupta yer alan bu kişiler süreç boyunca işbirliği halinde çalışacaktır. Ebeveynlerinin rehberliğinde, standart veya standart olmayan ölçme araçları sayesinde çocukların çeşitli yükseklik ve mesafe ölçümleri yapmaları sağlanır.
Fikirler planlar ve modeller (prototip) ile temsil edilir.	Çocuklar ve ebeveynlerin arabayı tamirciye kadar ilerletebilecek zincirleme reaksiyon sisteminin planını oluşturmalarına yardımcı olunur. Bu bir çizim, biz taslak, bir diyagram, bir model olabileceği gibi çocukların sözel olarak da ifade edebileceği bir plan olabilir. Ebeveynler çocuklarının planlarıyla ilgili çizim yapmalarına, fikirlerini sözlü olarak dile getirmelerine rehberlik eder, plana dair sözel açıklamalarını not ederler. Çocuklar çizimlerini bitirdiklerinde öğretmen tek tek yanlarına gider ve çocuğun problem durumunu anlayıp anlayamadığını çeşitli sorular aracılığıyla test eder. Örneğin; *"Sen papağanın bir problemini çözmek için düşündün ve bu planı çizdin öyle değil mi? Peki papağanın bu haftaki problemi neymiş?"* *"Papağan bu hafta bizden hangi konuda ona yardım etmemizi istiyor?"* Çocuğun planıyla ilgili detayları anlatmasını sağlamak için sorulabilecek sorular aşağıda örneklendirilmiştir. *"Nasıl bir sistem yapmayı planlıyorsunuz?"* *"Bu sistemi yapmak için hangi malzemeleri kullanmayı planlıyorsunuz?"* *"Tasarladığınız bu sistem nasıl çalışacak?"* Öğretmen, ebeveyn ve çocuklara ürettikleri bu fikirlerin problemi çözüp çözmeyeceğini görmeleri için, tıpkı mühendislerin yaptığı gibi, bu fikirleri yansıtan birer model inşa etmelerinin iyi bir fikir olacağını hatırlatır. Daha sonra gerçek bir yapının modelini yapmanın ne anlama geldiği üzerine tekrar konuşulur. Her grup kendi ürettiği en az iki fikirden istediği herhangi birini model aracılığıyla temsil eder. Model oluşturmada tasarım sırasında kullanılacak olan malzemelerin aynıları kullanılabilir.

Modeller test edilir.	Çocuklar ve ebeveynleri inşa ettikleri modelleri tamamlamış göründüklerinde sistemlerini test etmelerine yardımcı olunur ve yapılarının testi geçip geçemediğini, geçemediyse neden geçememiş olabileceği, geçtiyse neden geçmiş olabileceği değerlendirilir. Süreç bazı sorularla zenginleştirilir. *"Sistem arabayı tamirciye taşımayabiliyor mu? Sistemde kullanılan malzemelere misketin uygulayacağı kuvvet yeterli oldu mu?"* Test etme aşamasında öğretmen çocuklar ve ebeveynlerini tekrar tekrar denemeye teşvik etmelidir. Öğretmen çocuklara, gerçek mühendislerin de modeller üzerinde çalıştıklarını, bu modelleri sürekleri test ettiklerini ve bu denemeler sonucunda tasarımlarını geliştirdikleri hatırlatılır. Bu sonucun birazdan yapacakları tasarım için ne anlama geldiği sorulur *"Modelinizde bu malzemeyi kullanmıştınız ve modelini test ettiniz. Peki ne oldu? Arabayı tamirciye ulaştırabildiniz mi? Peki, bu modeli geliştirmek için ne yapmayı planlıyorsunuz?* gibi) karşılaşabilecekleri olası bir başarısızlık durumunda yeni çözümler üretmeleri için teşvik edilirler. Modellerini sınırlılıklar açısından test eden çocuklar ve ebeveynler bu deneyimlerinin olumlu veya olumsuz sonuçları doğrultusunda modellerini geliştirme yoluna giderler.
Tasarımlar inşa edilir.	Modeller test edildikten sonra, her grubun kafasında gerçek tasarımlarında hangi materyalleri kullanacaklarının netleşmesi beklenmektedir. Bunun yanı sıra, çocuklar modeller üzerinde yaptıkları çeşitli deneme yanılmalar sonucunda gerçek tasarımlarının nasıl görüneceği ve nasıl bir sistem oluşturmaları gerektiği hakkında daha net fikirlere sahip olacaktır. Modeller üzerinde yapılan deneme yanılmalar doğrultusunda her grup tasarımında kullanacağı malzemeleri seçer ve kendi tasarımını inşa etmeye başlar.
Tasarımlar denenir.	Tasarımların çalışıp çalışmayacağı konusunda sorgulama ve test etmek isteme açısından çocuklara model olunur. Tüm gruplar tasarladıkları sistemin arabayı tamirciye kadar götürüp götürmediğini test eder. Çocukların ve ebeveynlerinin denemeler sırasında ne olduğunu tanımlamalarına çeşitli sorular aracılığıyla yardımcı olunur. Örneğin; • *"Ne oldu?"* • *"Ne fark ettiniz"* • *"Tekrar denemek ister misiniz?"* • *"Sizce araba neden hareket etmedi?"* • *"Sizce misket neden durdu?"* • *"Peki misketi hızlandırmak için ne yapabiliriz?"* Bu etkinlikte zincirleme reaksiyonu başlatan nesne miskettir. İlk denemeler sırasında büyük misketler kullanılır ve eğer başarıya ulaşılmışsa daha küçük bir misketle süreç tekrarlanır. Daha sonra, sistem üzerinde reaksiyonu başlatan nesne olarak misket yerine başka nesneler de (top haline getirilmiş kağıt, top halinde pamuk, küp şeklinde bir ahşap blok gibi) kullanılabilir ve nesnelerin özellikleri, yapıldıkları malzeme gibi çeşitli kavramlar üzerine konuşulabilir. Ayrıca her gruptan neden bu materyali kullanmayı tercih ettiğini açıklaması istenir. Tasarımlar üzerinde kuvvet, eğim, hız gibi kavramlar hakkında konuşulur. Tüm tasarımlar denenmeden önce fotoğraflanır. • *"Tasarladığın bu sistemi bir misketle harekete geçirdik ve arabayı tamirciye kadar götürmeyi başardık. Fakat bu sistemde misket yerine pinpon topu kullandığımızda, arabayı hareket ettiremedik. Sence bunun nedeni ne olabilir?"* • *"Sence misketin ve pinpon topunun arabaya uyguladığı kuvvet aynı mı?"*

	• *“Ne yaparsak arabayı daha uzağa hareket ettirebiliriz?”*
Tasarımlar denemeler sonrasında geliştirilerek tekrar denenir.	Her grup tasarımlarını test edip sonuçları gördükten sonra, tasarımları üzerine tekrar düşünür ve tasarımlarını geliştirir. Etkinlik süresince çocuklar ve ebeveynlere farklı materyaller kullanarak tasarımlarını geliştirmeleri ve tekrar tekrar denemeleri için fırsat verilir. Denemeler çocuğun sürecin aşamalarını hatırlamasında yardımcı olması için mühendislik defterlerine eklenmek üzere fotoğraflanır.
Değerlendirme: Tüm çocukların ve ebeveynlerin deneyimlerini birbirleriyle paylaşmaları ve birbirlerinden öğrenmeleri için fırsat verilir.	Tüm gruplar mühendislik defterleri aracılığıyla diğer gruplara tasarım süreçlerini sunar. • *“Planınızda nasıl bir çözüm yolu çizmiştiniz bize de gösterir misiniz?”* • *“Modelinizde hangi malzemeyi/ malzemeleri kullanmıştınız?”* • *“Neden modelinizde bu malzemeyi kullanmayı tercih etmiştiniz?”* • *“Modelini denediniz değil mi? Peki ne oldu? Ne fark ettiniz?”* • *“Tasarımınızda hangi malzemeyi/malzemeleri kullandınız?”* • *“Neden modelinizde kullandığınız malzemeyi değiştirdiniz ve tasarımınızda farklı malzeme kullandınız?”* • *“Neden tasarımınızda bu malzemeyi kullanmayı tercih ettiniz?”* • *“Bu sistemin nasıl çalışacağını açıklayabilir misiniz?”* • *“Tasarımınızı denediniz mi? Peki denerken neler oldu?” Birlikte de deneyelim mi?”* • *“Sence tasarımınız papağanın problemini çözdü mü?”* • *“Tasarımınızı geliştirmek için başka neler yapmayı düşünüyorsunuz?”* • *“Bu sistemi nereden ilham alarak tasarladınız?”* Her bir grup tasarımını sunarken diğer çocukların da diğer grupların sistemlerinin planlarını, nasıl çalıştığını görmeleri ve diğer grupların fikirlerini değerlendirmelerine rehberlik edilir. *“Bu tasarım hakkında ne düşünüyorsun? Sence işe yarayacak mı?”* gibi. Gruplar birbirlerinin tasarımlarıyla ilgili detaylı sorular sormaları konusunda desteklenir. Öğretmen *“Bu tasarım nasıl çalışıyor? İlk olarak ne yapacağız? Peki, sonra neler olacak?”* gibi bir takım teşvik edici sorular sorabilir. Tüm gruplar tasarımlarını paylaştıktan sonra, öğretmen *“Şimdi tüm sistemleri bir araya getirip arabayı kuşun yuvasından ne kadar uzağa götürebileceğimize bakalım mı?”* der. Papağan görünür ve çocuklara birlikte harika bir iş çıkardıklarını, Deniz’in doğum gününe gidebileceği için çok mutlu olduğunu söyler ve teşekkür eder.

ÇOCUK GÖZLEM FORMU

Saygıdeğer gözlemci,

Bu gözlem formu ile, çocukların mühendislikle ilgili becerilerinin, eğilimlerinin ve duygularının değerlendirilmesi amaçlanmaktadır. Gözlem formu, o günün/haftanın aktivitesinde aşağıda ismini yazdığınız çocuğa ilişkin gözlemlerinizi içermelidir. Lütfen her hedef içindeki göstergeleri dikkatlice okuyunuz ve gözlemlediğiniz göstergelerin karşısındaki kutucuğu işaretleyiniz (X). Her kazanım için işaretleme işlemini tamamladıktan sonra, gözleminiz doğrultusunda, bu çocuğun ilgili etkinlikteki performansı hakkında genel bir değerlendirme yapınız. Etkinlikler sırasında göstergelerdeki ifadelerin tersi niteliğinde bir durum gözlemlediyseniz, lütfen bu durum/davranış/sözcüğü açıklama kısmına ayrıntılı olarak yazınız.

Gözlemcinin ünvanı: (Öğretmen/Araştırmacı)

Gözlemlenen çocuğun adı:

Gözlemlenen etkinliğin adı:

Beceriler Boyutu

S1. Gözlem ve araştırma yoluyla bir mühendislik ürünü geliştirerek çözülebilecek bir mühendislik problemini tanımlar.	
Göstergeler	***Davranış gözlemlendi mi?***
S1.1 Problemi veya ihtiyacı belirler.	
S1.2 Problemle ilgili ön bilgilerini gözden geçirir.	
S1.3 Problemle ilgili sorular sorar.	
S1.4 Problemi çözmekteki amacı belirler.	
S1.5 Problemi çözmek için kuralları (sınırlılıkları ve gereklilikleri) belirler.	
S1.6 Mevcut materyalleri sınırlılıklar açısından keşfeder.	
Açıklama (Etkinlik sırasında çocuk ile ebeveyn arasında geçen konuşmalar veya gözlemcinin kendi cümleleri).	

S2. Probleme olası çözümler üretir ve fikirlerini basit bir plan ve/veya model yoluyla ifade eder.	
Göstergeler	***Davranış gözlemlendi mi?***
S2.1 Materyallerin nasıl kullanılabileceği ve dönüştürülebileceği hakkında beyin fırtınası yapar.	
S2.2 Problemi çözmek için materyallerin birlikte nasıl kullanılabileceği hakkında beyin fırtınası yapar.	
S2.3 Problemi çözmek için fikir üretir.	
S2.4 Fikirlerini plan çizerek temsil eder ve/veya çözümün nasıl görüneceği ve nasıl çalışacağını sözel olarak ifade eder.	
S2.5 Model yapımında gerekli olan materyalleri belirler.	
S2.6 İnşa ettiği modeli dener.	
S2.7 Model üzerinde yaptığı denemeden yola çıkarak tasarımı için yeni fikirler üretir.	
Açıklama (Etkinlik sırasında çocuk ile ebeveyn arasında geçen konuşmalar veya gözlemcinin kendi cümleleri).	

S3. Bir tasarım inşa eder ve bu tasarımı geliştirmeye çalışır.	
Göstergeler	***Davranış gözlemlendi mi?***
S3.1 Problemi çözmek için tasarladığı planı takip eder.	
S3.2 Problemin sınırlılık ve gerekliliklerini göz önüne alarak tasarımı için uygun materyali seçer.	
S3.3 Materyaller üzerinde ebeveyni ile iş birliği halinde çalışır.	
S3.4 Problemi çözmek için bir tasarım inşa eder veya bir önceki adımda inşa ettiği modeli geliştirir.	
S3.5 Tasarımını test ettikten sonra problemi çözüm çözmediğine karar verir.	
S3.6 Test etme aşamasında neler olduğunu ve bunun tasarımın bir sonraki versiyonu için ne anlama geldiğini açıklar.	
S3.7 Tasarımını geliştirmeye yönelik fikirler üretip uygular.	
S3.8 Çeşitli geliştirme çabalarından sonra tasarımını amaca ulaşana kadar tekrar tekrar test eder.	
S3.9 Tasarımı problemin sınırlılık ve gerekliliklerine uygundur.	
S3.10 Tasarım sürecini ve tasarımının son halini diğer gruplarla paylaşır.	

S3.11 Başlangıç fikirlerini ve tasarımın son prototipini bu iki durum arasındaki farklara değinerek kıyaslar.	
Açıklama (Etkinlik sırasında çocuk ile ebeveyn arasında geçen konuşmalar veya gözlemcinin kendi cümleleri).	

S4. Bir mühendislik probleminin birden çok çözümü olabileceğini kavrar.	
Göstergeler	***Davranış gözlemlendi mi?***
S4.1 Aynı mühendislik problemine diğer gruplar tarafından önerilen çözümleri keşfeder.	
S4.2 Kendisine sunulan mühendislik problemi için tasarladığının dışında (tasarladığından farklı) olası çözüm fikirleri üretir.	
Açıklama (Etkinlik sırasında çocuk ile ebeveyn arasında geçen konuşmalar veya gözlemcinin kendi cümleleri).	

S5: Materyal seçiminin mühendislikteki kilit rolünü kavrar.	
Göstergeler	***Davranış gözlemlendi mi?***
S5.1 Belli bir materyali tasarımında neden kullandığını açıklar.	
Açıklama (Etkinlik sırasında çocuk ile ebeveyn arasında geçen konuşmalar veya gözlemcinin kendi cümleleri).	

S6: Matematikle ilgili bilgi ve becerilerini mühendislik tasarım problemlerine uygular.	
Göstergeler	***Davranış gözlemlendi mi?***
S6.1 Mühendislik tasarım sürecinde matematik bilgi ve becerilerinden yararlanır. o Sayılarla çalışma (nesneleri sayma, sayıları tanıma) o Nicelik bilgisi (bir dizide yer alan nesne sayısını bilme) o İlişki belirten ifadeler kullanma (nesnelerin sayıları/miktarları arasında daha fazla, daha az, eşit gibi ilişkiler kurabilme) o Basit toplama çıkarma	
S6.2 Mühendislik tasarım sürecinde geometri, uzamsal düşünme ve ölçme gibi alanlardaki bilgi ve becerisinden yararlanır. o Mekânda konum ile ilgili ifadeler kullanma (altında, üstünde, yanında). o İki ve/veya üç boyutlu geometrik şekiller hakkında bilgi sahibi olma ("Anne bak, dikdörtgen bir çatı yapmak için iki üçgeni birleştirdim.") o Geometrik şekilleri ayırarak ve birleştirerek yeni şekiller oluşturma. o Çevresinde gördüklerini zihninde canlandırma. o Çevresindeki nesnelerin büyüklük-küçüklük ve konum bakımından ilişkisine uygun modeller yaratma. o Nesneleri standart ve standart olmayan ölçme araçlarıyla ile ölçme.	
Açıklama (Etkinlik sırasında çocuk ile ebeveyn arasında geçen konuşmalar veya gözlemcinin kendi cümleleri).	

S7: Fen bilgisini mühendislik tasarım problemlerine uygular.	
Göstergeler	***Davranış gözlemlendi mi?***
S7.1 Mühendislik tasarım sürecinde fen ile ilgili bilgisinden (canlı/cansız varlıklar, yaşam alanları, çevresel ihtiyaçlar ve bitki ve hayvanları spesifik özellikleri, doğada meydana gelen değişimler, doğal materyaller, bilimsel kavramlar).	
Açıklama (Etkinlik sırasında çocuk ile ebeveyn arasında geçen konuşmalar veya gözlemcinin kendi cümleleri).	

Eğilimler Boyutu (Düşünme Becerileri)

Meraklı Düşünme (D1)	
Göstergeler	***Davranış gözlemlendi mi?***
D1.1 Yeni şeyler öğrenme ve yeni deneyimler edinme konusunda isteklidir.	
D1.2 Gözlemlenebilir durumları gözlemler ve gözlemleri hakkında sorular sorar.	
D1.3 Giderek daha bağımsız seçimler yapar.	
D1.4 Çok sayıda konu ve fikri öğrenmek için isteklidir.	
D1.5 Bilgi almak için sorular sorar.	
D1.6 Basit araç gereçleri kullanarak araştırmalar planlar ve uygular.	
D1.7 Problemlere çözümler üretmenin yollarını araştırır ve keşfeder.	
Açıklama (Etkinlik sırasında çocuk ile ebeveyn arasında geçen konuşmalar veya gözlemcinin kendi cümleleri).	

Israrcı Düşünme (D2)	
Göstergeler	***Davranış gözlemlendi mi?***
D2.1 Başarılı olana kadar birkaç kez dener.	
D2.2 Problemi çözmek için bir plan hazırlayıp yürütür.	
D2.3 Planlamayı ve amacının peşinden gitmeyi amaca ulaşana kadar sürdürür.	
D2.4 Yönlendirme ve bölünmelere rağmen çalışmasına uzun süre dikkatini verebilir.	
D2.5 Çözümü test eder ve test sonuçlarına göre çözümü üzerinde değişiklikler yapar.	
Açıklama (Etkinlik sırasında çocuk ile ebeveyn arasında geçen konuşmalar veya gözlemcinin kendi cümleleri).	

Esnek Düşünme (D3)	
Göstergeler	*Davranış gözlemlendi mi?*
D3.1 Bir problemi çözmek için farklı yollar önerir.	
D3.2 Problem için önerdiği çözümü gerçekten denemeden önce çeşitli yollarla (plan, taslak, model gibi) temsil eder.	
D3.3 Bir problemi çözmek için girişimde bulunduğunda uyum yeteneği, hayal gücü ve icat kabiliyeti sergiler.	
D3.4 Diğer insanların problemleri nasıl çözdüklerini gözlemler ve örnek alır.	
D3.5 Diğer insanların fikir ve önerilerine açıktır.	
D3.6 Kendini en az yardım ile yeni durumlara ve insanlara alıştırır.	
D3.7 Problemi tüm olasılıkları denemek zorunda kalmadan çözer.	
D3.8 Sahip olduğu fikirleri yeni durumlara uygular.	
D3.9 Denemeler sırasında başarısızlıkla karşılaştığında tasarımını sürekli baştan yapmak istemek yerine zaten var olan tasarımını geliştirmeye odaklanır.	
D3.10 Problemler üzerinde çeşitli olasılıkları göz önünde bulundurarak ve sonuçları analiz ederek düşünür.	
Açıklama (Etkinlik sırasında çocuk ile ebeveyn arasında geçen konuşmalar veya gözlemcinin kendi cümleleri).	

Yansıtıcı Düşünme (D4)	
Göstergeler	*Davranış gözlemlendi mi?*
D4.1 Deneyimlerini ve düşüncelerini belgeler (dökümanlar aracılığıyla).	
D4.2 Deneyimleri hakkında onları anlamak ve değerlendirmek için konuşur.	
D4.3 Yetişkin desteği aracılığıyla kişisel deneyimlerini hatırlar ve sıralar.	
D4.4 Günlük yaşam deneyimlerine yönelik bilgisini yeni durumlara uygular.	
D4.5 Neler olup bittiği hakkında deneyime dayalı teoriler oluşturur.	
Açıklama (Etkinlik sırasında çocuk ile ebeveyn arasında geçen konuşmalar veya gözlemcinin kendi cümleleri).	

İşbirlikçi Düşünme (D5)	
Göstergeler	*Davranış gözlemlendi mi?*
D5.1 Başkalarının bir durumla ilgili duygularının kendisininkinden farklı olabileceğini kabul eder.	
D5.2 Bir görev üzerinde grubun diğer üyeleri ile çalışırken (ebeveyni/yaşıtları) sırasını bekler.	
D5.3 Görev üzerinde planlama yapmak, rolleri paylaşmak ve iş birliği yapmak için diğer grup üyeleri ile etkileşim kurar.	
D5.4 Bir görev hakkındaki düşüncelerini grubun diğer üyeleri ile paylaşır.	
D5.5 Bir görevle ilgili sosyal çatışmaları çözmek için müzakere eder.	
Açıklama (Etkinlik sırasında çocuk ile ebeveyn arasında geçen konuşmalar veya gözlemcinin kendi cümleleri).	

Duygular Boyutu

Kazanımlar	*Göstergeler*	*Davranış gözlemlendi mi?*
F1: Bir mühendis gibi çalışmaktan hoşnut görünür.	**F1.1** Mühendislik etkinliklerine katılmaya hevesli görünür.	
	F1.2 Etkinliklere sıkılmadan ve dikkati dağılmadan dahil olur	
F2: Yardıma ihtiyaç duyan insanlara veya karakterlere yardım etmekten hoşnut görünür.	**F2.1** Papağan ve arkadaşlarının sorunlarına ilgi gösterir.	
	F2.2 Kendisine sunulan probleme çözüm üretmekten memnun görünür.	
F3: Etkinlikler sırasında ebeveyni ile çalışmaktan memnun görünür.	**F3.1** Anne ve/veya babası ile birlikte mühendislik tasarım sürecini deneyimlemekten memnun görünür.	
F4: Etkinliklerde açık uçlu materyalleri kullanmaktan memnun görünür.	**F4.1** Tasarımında kullanmak üzere açık uçlu materyalleri keşfederken heyecanlıdır.	
	F4.2 Açık-uçlu materyallerle tasarım yapmaktan hoşnut görünür.	
F5: Sunulan probleme çözüm ürettikleri için ebeveyni ve kendisi ile gurur duyar.	**F5.1** Anne ve/veya babası ile yaptığı tasarımı diğer gruplarla paylaşırken başarısından dolayı mutlu görünür.	
	F5.2 Tasarımının problemi nasıl çözeceğini diğer gruplara ve öğretmenine anlatırken mutludur.	
F6: Mühendisliği olası bir kariyer alanı olarak görür.	**F6.1** İleride hangi mesleği yapmak istediği sorulduğunda mühendis olabileceğini söyler.	
NF1: Etkinlikten sıkılır ve/veya dikkati dağınıktır.	**NF1.1** Etkinlik süreci devam ederken eve gitmek istediğini söyler.	
	NF1.2 Etkinlik sırasında etkinliği bırakıp başka şeylerle meşguldür.	
NF2: Başarısızlık nedeniyle hayal kırıklığı gösterir.	**NF2.1** Kendisine sunulan problemi çözerken başarısız olması durumunda hayal kırıklığına uğramış görünür.	
NF3: Açık-uçlu materyallerle çalışmaktan hoşnut değildir.	**NF3.1** Etkinlik sırasında tasarım yapmaları için kendilerine sunulan açık-uçlu materyalleri kullanmak istemediğini ifade eder.	
	NF3.2 Etkinlik sırasında tasarım yapmaları için kendilerine sunulan açık-uçlu materyalin yerine başka materyaller kullanma arzusunu dile getirir (“Keşke … mız olsaydı. Onunla ne güzel şeyler yapardık.”)	

Açıklama
(Etkinlik sırasında çocuk ile ebeveyn arasında geçen konuşmalar veya gözlemcinin kendi cümleleri).

Appendix L. Sample Scaffolding Cases for Parent Training

Problem: 4 yaşındaki kızınızın doğum günü. Evinize kızınızın sınıf arkadaşlarını çağırdınız. Kızınız bir grup kız çocuğu ile birlikte yanınıza gelerek erkek çocukların odanın bir köşesine barikat kurduklarını ve kızların bu köşedeki arabalarla oynamasına izin vermediklerini söylüyor. Kızlar erkeklere kızmışlardır ve sizden bir şeyler yapmanızı istiyorlar.

Anne: "Sizin de arabalarla oynamak istediğinizi ve erkeklerin yaptığı bu davranışa sinirlendiğinizi görebiliyorum. Böyle davranmaları beni de üzdü. Bununla ilgili ne yapmak istersiniz?
Çağlar: "Onlara bunu yapamayacaklarını söyleyebilirsin anne."
Anne: "Birlikte neler yapabileceğimizi düşünmenizi istiyorum?"
Çağlar: "Çok zor."
Anne: "Peki, daha farklı neler yapabileceğimiz hakkında konuşalım. Erkeklere arabaların başından ayrılmalarını söyleyebilirim. Fakat o zaman da onlar üzülmezler mi? Hepimizi memnun edecek bir çözüm yolu bulmalıyız."
Meryem: "Biz (Çağları ve kendisini işaret ediyor) onlara anlatabiliriz."
Anne: "Nasıl anlatacaksınız?"
Meryem: "Hep birlikte anlatabiliriz, sen de bize yardım eder misin?"
Anne: "Tabi. Siz erkeklerle konuşurken yanınızda bulunurum fakat onlarla siz konuşmalısınız. Hepiniz aynı anda konuşmak ister misiniz? Bu hepinizin birlikte anlatacağı anlamına mı geliyor?"
Çağlar: "Hep bir ağızdan şarkı söyleyebiliriz, hep birlikte."
Anne: "Ne dersiniz? Denemek ister misiniz?"
Kızlar: "Evet hadi deneyelim."
Anne: "Şarkınızda onlara ne söylemek istersiniz?"

5 yaşındaki çocuğunuz oyuncaklarıyla kule yapıyor. Çocuğunuzun yanına oturuyorsunuz ve kulesini daha sağlam yapabilmesi için birkaç öneride bulunuyorsunuz. Sonraki süreçte de çocuğunuzu yapı inşa oyuncaklarıyla oynarken gözlemliyorsunuz fakat yaptığı kule henüz tamamlanmadan yıkıldığında çok çabuk pes ettiğini fark ediyorsunuz. Çocuk kuleyi tamamlayana kadar tüm girişimlerinde yanında oturup aynı şekilde destek veriyorsunuz. **YANINA HER OTURDUĞUNUZDA SİZİN ONUN ÇABASINI DESTEKLEDİĞİNİZ VE TAKDİR ETTİĞİNİZ MESAJINI ALIYOR.**

11 aylık Ece destek alarak ve iterek yürüdüğü arabayı bırakıyor.
Yanında oturmakta olan babası «Merhaba tatlım» diyor, eline doğru uzanıyor.
Ece bir adım daha atıyor, sonra bir adım daha ve daha sonra düşüyor.
Ece nasıl tepki verdiğini görmek için babasına bakıyor.
Babası «Boom. Düştün, ama iyisin. Tekrar denemek ister misin?»
Ece kollarını uzatıyor ve babası kalkmasına yardımcı oluyor.
Ece ayakta durana kadar babası ellerini tutuyor, daha sonra her iki eline de birer küçük oyuncak veriyor. Böylece çocuk kendi başına dengede durabiliyor.
Babası «Tamam, Ece, bana doğru yürüyebilir misin?» diyor.
Ece iki oyuncağı sıkıca tutarak üç adım atıyor ve düşmeden önce babasına ulaşıyor.

Appendix M: Sample Parent Consent Form

Ebeveyn Onay Formu

Saygıdeğer anne/baba

Bu form tarafınıza Kastamonu Üniversitesi Eğitim Fakültesi Okul Öncesi Eğitimi Anabilim Dalı araştırma görevlisi Aysun Ata Aktürk tarafından ulaştırılmıştır. Formda sizlere Orta Doğu Teknik Üniversitesi Temel Eğitim Bölümü Okul Öncesi Eğitimi Anabilim Dalı'nda yürütmekte olduğum doktora tezime yönelik bilgiler sunulmaktadır. Aşağıda detayları verilen bu çalışmanın öğretmenimiz …, siz velilerimiz ve çocuklarımızla gerçekleştirilmesi hedeflenmektedir ve siz değerli velilerimizden katılımınıza yönelik bilgi vermeniz talep edilmektedir. Çalışmaya çocukla birlikte, ebeveynlerin her ikisi (hem anne hem baba) ya da ebeveynlerden yalnızca biri (sadece anne ya da sadece baba) katılabilir.

Çalışmanın Amacı Nedir?
Bu çalışmanın amacı çocuğunuzla birlikte gönüllü olarak katılımınıza dayanan, çocuğunuzun öğretmeni (…) ve araştırmacının (Aysun Ata Aktürk) rehberliğinde gerçekleşecek olan 5 haftalık bir atölye çalışması aracılığıyla, çalışma kapsamında geliştirilen "*Okul Öncesi Dönemde Ebeveyn Katılımı Temelli Mühendislik Tasarım Müfredatı*" etkinliklerini uygulamaktır. Bir diğer deyişle, bu çalışma bir bilim insanı gibi düşünen, araştıran, sorgulayan, merak eden, günlük yaşam problemlerinin farkında olup bu problemlere etkili çözümler üreten okul öncesi dönem çocuğunuz için okulda ve evde uygulanabilecek, onları problem çözme ve üst düzey düşünme konusunda geliştirmeyi hedef alan mühendislik tasarım müfredatını çocuğunuzla birlikte katılacağınız atölye çalışmalarında uygulamayı amaçlamaktadır. Çalışma aynı zamanda, atölyede gerçekleştirilecek olan etkinlikleri siz değerli anne babalar, değerli öğretmenimiz ve çocuklarımızın gözünden değerlendirmeyi hedeflemektedir.

Bize Nasıl Yardımcı Olmanızı İsteyeceğiz?
Araştırma 2018-2019 eğitim öğretim yılı bahar döneminde (Ekim ayı boyunca ve Kasım ayının ilk iki haftasında) **toplamda 5 hafta sonu** sadece **CUMARTESİ** günleri **13:00-16:30** saatleri arasında Kastamonu Üniversitesi Eğitim Fakültesinde **"Ebeveyn-Çocuk Mühendislik Tasarım Atölyesi"** adıyla gerçekleştirilecektir. Çalışmada siz anne-babalardan hiçbir ücret talep edilmeyecek olup, sadece cumartesi günleri yukarıda belirtilen yer ve saatte bulunmanız, öğretmenimiz tarafından araştırmacı Aysun Ata Aktürk rehberliğinde uygulanacak olan etkinliklere çocuğunuzla birlikte devamsızlık olmaksızın katılmanız ve çalışmanın başında ve sonunda sizlere sorulacak olan görüşme sorularını yanıtlamanız beklenmektedir.

Katılımınızla İlgili Bilmeniz Gerekenler
Bu çalışmaya katılmak tamamen gönüllülük esasına dayanmaktadır. Araştırmaya katılanlardan toplanan veriler tamamen gizli tutulacak olup, tarafınıza ait bilgiler kimse ile paylaşılmayacaktır. Toplanan verilere ve kişisel bilgilerinize sadece araştırmacılar ulaşabilecektir. Bu araştırmanın sonuçları bilimsel ve profesyonel yayınlarda veya eğitim amaçlı kullanılabilir, fakat katılımcıların kimliği gizli tutulacaktır.

Araştırmayla ilgili daha fazla bilgi almak isterseniz
Çalışmayla ilgili soru ve yorumlarınızı tarafıma aata@kastamonu.edu.tr e-mail adresi ya da … telefon numarası aracılığıyla ulaştırabilirsiniz.
(Çalışmaya katılmak istiyorsanız formu imzaladıktan sonra en geç … gününe kadar öğretmen …'na teslim ediniz).

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılmak isterim.

Velinin İsmi: ………………. **İmza**
Telefon numarası: ………………

Appendix N: The Task Checklist Used by The Teachers

GÖREVLER	**X**
Problem durumu çocuklara tanıtılır	
• Bir önceki hafta yapılanlar hatırlanır (Çocuklar mühendislik defterlerine bakarlar ve hangi adımlardan geçtikleri sorulur)	
• Süreç sorularla pekiştirilir.	
• Papağan ve kaplumbağa aracılığıyla haftanın problem durumu tanıtılır.	
• Çocukların fikirleri tahtaya yazılır (kaplumbağayı nehirden karşıya geçirmek için ne yapabiliriz?)	
Çocukların problem-çözme amacını anlamalarına yardım edilir.	
• "Çocuklar mühendislik yapmaya hazır mısınız? Ama öncesinde biraz düşünelim sizce köprüler ne işe yarar?"	
• "Daha önce köprü gören ya da bir köprüden geçen var mı?"	
• "Gördüğün bu köprüden kimler geçiyordu?"	
• "Köprülerden başka kimler geçebilir?"	
• "Köprüleri hangi mühendisler tasarlar?"	
Sınırlılıklar belirlenir.	
• Sınırlılıklar hakkında konuşulur	
Tasarım planı çizilir	
• Materyaller keşfedilir.	
• Çizimler üzerine konuşulur (senin köprünün şekli nasıl olacak; geçiş nereden olacak, bu köprüden kimler geçecek)	
Fikirler modeller (prototype) ile temsil edilir.	
• Gerçek bir yapının modelini yapmanın ne anlama geldiği üzerine konuşulur.	
• Açık uçlu materyaller kullanılarak modeller inşa edilir	
Modeller test edilir.	
• İnşa edilen modeller sınırlılıklar açısından test edilir.	
• Test sonucunda ne olup bittiği çocuğa sorulur.	
• Bu sonucun tasarımı için ne anlama geldiği sorulur	
Tasarımlar inşa edilir.	
• Gruplar materyallerini seçerler.	
• Tasarımlar yaratılır.	
Tasarımlar denenir.	
• Her çocuk kendi tasarımını dener	
• Bu sırada öğretmen çeşitli sorularla deneme sürecini zenginleştirir.	
Tasarımlar denemeler sonrasında geliştirilerek tekrar denenir.	
• Tasarımını deneyen çocuklara tasarımını nasıl geliştireceği sorulur.	
• Tasarımlar geliştirilip tekrar tekrar denenir.	
Tüm çocukların ve ebeveynlerin deneyimlerini birbirleriyle paylaşmaları için fırsat verilir.	
• Çocuklar tek tek gelip tasarımlarını tanıtırlar	
• Sen nasıl bir köprü inşa ettin?	
• Bu köprüden kimler geçecek?	
• Neden bu malzemeyi kullanmayı tercih ettin?	
• İlk denemende başarılı oldun mu?	
• Peki sonra tasarımını geliştirmek için ne yaptın?	
• Köprün kaplumbağanın geçebileceği kadar geniş mi?	
• Köprün kaplumbağayı taşıyacak kadar sağlam mı?	
• Vaktimiz olsa bu köprüye başka bir şey eklemek ister miydin?	
• Dünyanın çeşitli yerlerinden farklı köprü örnekleri sunulur.	

Appendix O: Final Prototype of the EDCPI Learning Objectives (In English)

Knowledge-related Learning Objectives of the EDCPI

Learning objectives	Relevant indicators
K1: The child comprehends the meaning of engineering.	**K1.1** Tells what engineers do
	K1.2 Expresses that engineers are working to make human life easier and meet people's needs
K2: The child recognizes the engineering products used in everyday life.	**K2.1** Exemplifies technologies s/he sees around her/him
	K2.2 Distinguishes natural objects from human-made objects
K3: The child discovers different fields of engineering.	**K3.1** Gives examples to technologies produced by engineers from different fields
	K3.2 Explains how engineering is effective in many areas of the human world
K4: The child comprehends that everyone can be an engineer or think like an engineer.	**K4.1** Gives examples to engineers from different genders and to technologies they produced
	K4.2 Gives examples of situations in which s/he or someone around him/her thinks like an engineer and produces a solution
K5: The child comprehends the role of engineering and technology in the development of our world and society.	**K5.1** Compares today's conditions with those of the past when engineering and technology were not developed
	K5.2 Gives examples of how engineering and technology affect the society (positively or negatively).

Skill-related Learning Objectives of the EDCPI

Learning objectives	Relevant indicators
S1: The child identifies an engineering problem which can be solved by developing an engineering product through observation and inquiry.	**S1.1** Identifies the problem or the need. **S1.2** Reviews her/his prior knowledge about the problem. **S1.3** Asks questions about the problem. **S1.4** Determines the problem-solving goal. **S1.5** Identifies the constraints (limitations) and criteria (requirements) for solving the problem. **S1.6** Explores available materials in respect to the limitations of the problem.
S2: The child develops possible solution idea(s) and reflects this/these on a simple plan and model.	**S2.1** Brainstorms ideas on how materials can be used and modified. **S2.2** Brainstorms ideas on how the materials can be used together to solve the problem. **S2.3** Produces an idea to solve the problem. **S2.4** Draws a plan, constructs a model, and/or verbally expresses how the solution will look and act. **S2.5** Determines the materials s/he will need while constructing a model. **S2.6** Test the model s/he constructed. **S2.7** Produces new ideas for design based on her/his experiment on the model.
S3: The child constructs her/his design and tries to improve it.	**S3.1** Follows the plan s/he drawn or expressed to solve the problem. **S3.2** Chooses appropriate materials for the design by taking the constraints of the problem into consideration. **S3.3** Works collaboratively with her/his parents by using hands-on materials. **S3.4** Constructs a design to solve the problem or improves the model s/he constructed in the previous step. **S3.5** After testing her/his design, s/he decides whether it solved the problem. **S3.6** Describes what happened when testing and what the result refers to the next version. **S3.7** Implements her/his improvement ideas to the solution. **S3.8** Tests it again after the improvements until the design satisfies the goal. **S3.9** The design complies with the limitations and requirements of the problem. **S3.10** Shares the final version of the design with other children and parents. **S3.11** Compares her/his initial ideas and final prototype of her7his design by pointing differences between these two conditions.
S4: The child comprehends that it is possible to solve a design problem through multiple ways.	**S4.1** S/he explores the solutions produced by her/his peers for the engineering problem. **S4.2** Except for what s/he designed for an engineering problem; s/he produces different possible solution ideas.

S5: The child comprehends that the utilized materials and the features of these materials have a critical role in engineering solutions.	**S5.1** Explains why s/he used specific materials in her/his design.
S6: The child utilizes her/his math-related knowledge and skills to solve engineering design problems.	**S6.1** Utilizes his/her knowledge and skills about the subjects of the whole number, relations, operations to solve the engineering problem. • Working with number (e.g. counting) • Cardinality (e.g. knowing how many objects are in a set) • Relations (e.g. establishing relations such as more than, less than, or equal to) • Operations (addition and subtraction) **S6.2** Utilizes his/her knowledge and skills about geometry, spatial thinking, measurement to solve the engineering problem. • Having knowledge about space (below, above, beside). • Having knowledge about two or three-dimensional geometric shapes (e.g. “Look Mom, I combined two triangle blocks to make a rectangle roof”). • Taking geometric shapes apart and putting them back to form new shapes. • Utilizing mental representations of the environment • Creating models representing relationships between objects in the environment • Comparing lengths, heights, and other features by using standard or nonstandard measurement tools.
S7: The child applies her/his science knowledge to address an engineering problem.	**S7.1** Utilizes her/his science-related knowledge (e.g. living/nonliving things, habitats, environmental needs and specific characters of plants and animals, characteristics and changes in the natural world, weather and seasons, natural materials, scientific concepts) during EDP.

Dispositions-related Learning Objectives of the EDCPI

Dispositions	Indicators
D1. Curious Thinking	**D1.1** Shows interest in learning new things and trying new experiences. **D1.2** Makes observations and poses questions about observable situations. **D1.3** Becomes increasingly independent in her/his selections. **D1.4** Shows a willingness to learn various topics and ideas. **D1.5** Poses questions to obtain information. **D1.6** Plans and carries out investigations utilizing simple equipment. **D1.7** Investigates and finds out the ways to produce solutions to the problems.
D2. Persistent Thinking	**D2.1** Makes many trials until s/he reaches success. **D2.2** Designs and carries out a plan to solve a problem. **D2.3** Continues to plan and pursue her/his aim until s/he reaches it. **D2.4** In spite of redirections or distractions, s/he can recollect her/his attention for a long time in the design process. **D2.5** Tests his / her solutions and makes changes on the design / model according to the test results.
D3. Flexible Thinking	**D3.1** Suggests different ways of solving a problem. **D3.2** Represents his/her idea of a solution by means of a sketch, a model, or verbal expression before trying it. **D3.3** While trying to solve a problem, s/he exhibits imagination, inventiveness, and the ability to adapt to new situations. **D3.4** Observes and inspires other people's ways of solving problems. **D3.5** S/he is open to the opinions and suggestions of parents or peers. **D3.6** Adapts to new people and situations through minimal assistance. **D3.7** Solves problems without being obliged to try all the possibilities. **D3.8** Implements her/his ideas to new situations. **D3.9** When s/he fails during trials, s/he focuses on developing her/his current design instead of making a new one. **D3.10** Thinks on the problems by considering the various possibilities and by analyzing the results.
D4. Reflective Thinking	**D4.1** Documents his/her experiences and thoughts. **D4.2** Talks about his/her experiences to evaluate and understand them. **D4.3** When support is provided, s/he remembers her/his personal experiences and their sequence. **D4.4** Uses her/his knowledge of daily experiences in the new context. **D4.5** Establishes theories based on experience with regard to what might happen.

D5. Collaborative Thinking	**D5.1** Recognizes and acknowledges that other people’s feelings and thoughts related to a situation might differ from his/her own ones. **D5.2** Waits for her/his turn while working on a task. **D5.3** Interacts with her/his parents and peers in the group to plan, coordinate roles, and cooperate on the task. **D5.4** Communicates her/his thoughts about a task to her/his parents and her/his peers. **D5.5** Negotiates with the group members to resolve conflicts in a task.

Feelings-related Learning Objectives of the EDCPI

Learning Objectives	Indicators
F1: The child likes to work as an engineer.	**F1.1** S/he appears enthusiastic to participate in engineering activities.
	F1.2 S/he participates in activities without being distracted.
F2: The child likes to help people or characters who have a problem.	**F2.1** S/he is interested in the problems of the parrot and his/her friends.
	F2.2 S/he seems happy to produce solutions to the problems presented to him/her.
F3: The child is pleased by work with her/his parent.	**F3.1** S/he seems happy to experience EDP with his/her parent(s).
F4: The child is pleasured by use open-ended materials in engineering activities.	**F4.1** S/he seems pleased to make designs with open-ended materials.
	F4.2 S/he seems excited to discover open-ended materials to be used in engineering design activities.
F5: The child is proud of himself/herself and his/her parent because they create a design of a solution to the problem offered to them.	**F5.1** S/he seems happy with her/his success while presenting her/his design and telling about her/his engineering process to other groups.
	F5.2 S/he seems happy when s/he tells other groups and teachers how his/her design will solve the problem.
F6: The child considers engineering as a possible career.	**F6.1** S/he says that s/he can be an engineer when asked about which profession s/he wants to choose.

Appendix P. Child Observation Form (In English)

Dear observer,

In this observation form, it is aimed to evaluate children's engineering-related skills, dispositions, and feelings. This observation form should include observations related to the child you wrote her/his name below in the activity that day/week. Please read the indicators within each objective and place an X in the box opposite the indicator or indicators you observed. After completing the markings, make a general assessment on this child's performance in the relevant activity in the light of your observation. If during your observations you have observed the opposite of the statements in the indicators, please write this in detail.

Title of Observer: (Teacher/Researcher)

Name of Observed Child:

Name of the Activity:

Skills Dimension

S1. The child identifies an engineering problem which can be solved by developing an engineering product through observation and inquiry**.**	
Indicators	***Has the behavior been observed?***
S1.1 Identifies the problem or the need.	
S1.2 Reviews her/his prior knowledge about the problem.	
S1.3 Asks questions about the problem.	
S1.4 Identifies the constraints (limitations) and criteria (requirements) for solving the problem.	
S1.5 Explores available materials in respect to the limitations of the problem.	
Explanation (A conversation between the child and the parent during the event or your own sentences).	

S2: The child develops possible solution idea(s) and reflects this/these on a simple plan and model**.**	
Indicators	***Has the behavior been observed?***
S2.1 Brainstorms ideas on how materials can be used and modified.	
S2.2 Brainstorms ideas on how the materials can be used together to solve the problem.	
S2.3 Produces an idea to solve the problem.	
S2.4 Draws a plan, constructs a model, and/or verbally expresses how the solution will look and act.	
S2.5 Determines the materials s/he will need while constructing a model.	
S2.6 Test the model s/he constructed.	
S2.7 Produces new ideas for design based on her/his experiment on the model.	
Explanation (A conversation between the child and the parent during the event or your own sentences).	

S3. The child constructs her/his design and tries to improve it**.**	
Indicators	***Has the behavior been observed?***
S3.1 Follows the plan s/he drawn or expressed to solve the problem.	
S3.2 Chooses appropriate materials for the design by taking the constraints of the problems into consideration.	
S3.3 Works collaboratively with her/his parents by using hands-on materials.	
S3.4 Constructs a design to solve the problem or improves the model s/he constructed in the previous step.	
S3.5 After testing her/his design, s/he decides whether it solved the problem.	
S3.6 Describes what happened when testing and what the result refers to the next version.	
S3.7 Implements her/his improvement ideas to the solution.	
S3.8 Tests it again after the improvements until the design satisfies the goal.	
S3.9 The design complies with the limitations and requirements of the problem.	
S3.10 Shares the final version of the design with other children and parents.	
S3.11 Compares her/his initial ideas and final version of the design by pointing differences between these two conditions.	

Explanation (A conversation between the child and the parent during the event or your own sentences).

S4: The child comprehends that it is possible to solve a design problem through multiple ways**.**	
Indicators	***Has the behavior been observed?***
S4.1 S/he explores the solutions produced by her/his peers for the engineering problem.	
S4.2 Except for what s/he designed for an engineering problem; s/he produces different possible solution ideas.	
Explanation (A conversation between the child and the parent during the event or your own sentences).	

S5: The child comprehends that the utilized materials and the features of these materials have a critic in engineering solutions**.**	
Indicators	***Has the behavior been observed?***
S5.1 Explains why s/he used specific materials in her/his design.	
S5.2 Makes explanations about the properties of the materials s/he used in prior and last prototypes of the design.	
Explanation (A conversation between the child and the parent during the event or your own sentences).	

<table>
<tr><td colspan="2">S6: The child utilizes her/his math-related knowledge and skills to solve engineering design problems.</td></tr>
<tr><td>Indicators</td><td>Has the behavior been observed?</td></tr>
<tr><td>S6.1 Utilizes his/her knowledge and skills about the subjects of the whole number, relations, operations to solve the engineering problem.
• Working with number (e.g. counting)
• Cardinality (e.g. knowing how many objects are in a set)
• Relations (e.g. establishing relations such as more than, less than, or equal to)
• Operations (addition and subtraction)</td><td></td></tr>
<tr><td>S6.2 Utilizes his/her knowledge and skills about geometry, spatial thinking, measurement to solve the engineering problem.
• Having knowledge about space (below, above, beside).
• Having knowledge about two or three-dimensional geometric shapes (e.g. “Look Mom, I combined two triangle blocks to make a rectangle roof”).
• Taking geometric shapes apart and putting them back to form new shapes.
• Utilizing mental representations of the environment
• Creating models representing relationships between objects in the environment
• Comparing lengths, heights, and other features by using standard or nonstandard measurement tools.</td><td></td></tr>
<tr><td colspan="2">Explanation
(A conversation between the child and the parent during the event or your own sentences).</td></tr>
</table>

<table>
<tr><td colspan="2">S7: The child applies her/his science knowledge to address an engineering problem.</td></tr>
<tr><td>Indicators</td><td>Has the behavior been observed?</td></tr>
<tr><td>S7.1 Utilizes her/his science-related knowledge (e.g. living/nonliving things, habitats, environmental needs and specific characters of plants and animals, characteristics and changes in the natural world, weather and seasons, natural materials, scientific concepts) during EDP.</td><td></td></tr>
<tr><td colspan="2">Explanation
(A conversation between the child and the parent during the event or your own sentences).</td></tr>
</table>

Dispositions Dimension

Curious Thinking	
Indicators	**Has the behavior been observed?**
• Shows interest in learning new things and trying new experiences.	
• Makes observations and poses questions about observable situations.	
• Becomes increasingly independent in her/his selections.	
• Shows a willingness to learn various topics and ideas.	
• Poses questions to obtain information.	
• Plans and carries out investigations utilizing simple equipment.	
• Investigates and finds out the ways to produce solutions to the problems.	
Explanation (A conversation between the child and the parent during the event or your own sentences).	

Feelings Dimension

Learning Objectives	*Indicators*	**Has the behavior been observed?**
• **F1:** The child likes to work as an engineer.	**F1.1** S/he appears enthusiastic to participate in engineering activities.	
	F1.2 S/he participates in activities without being distracted.	
• **F2:** The child likes to help people or characters who have a problem.	**F2.1** S/he is interested in the problems of the parrot and his/her friends.	
	F2.2 S/he seems happy to produce solutions to the problems presented to him/her.	
• **F3:** The child is pleased by work with her/his parent.	**F3.1** S/he seems happy to experience EDP with his/her parent(s).	
• **F4:** The child is pleasured by use open-ended materials in engineering activities.	**F4.1** S/he seems pleased to make designs with open-ended materials.	
	F4.2 S/he seems excited to discover open-ended materials to be used in engineering design activities.	
• **F5:** The child is proud of himself/herself and his/her parent because they create a design of a solution to the problem offered to them.	**F5.1** S/he seems happy with her/his success while presenting her/his design and telling about her/his engineering process to other groups.	
	F5.2 S/he seems happy when s/he tells other groups and teachers how his/her design will solve the problem.	
• **NF**1: The child appears bored of activity.	**NF1.1** S/he says that s/he wants to go home or gets bored while the activity is in progress.	
	NF1.2 S/he leaves the activity and engage with other things.	
• **NF2:** Indicates disappointment due to failure.	**NF2.1** S/he seems frustrated when s/he and her/his parent(s) fail to resolve the problem presented to them	
• **NF3:** S/he seems disgruntled to work with open-ended materials.	**NF3.1** S/he expresses that s/he does not want to use the open-ended materials that are offered to make designs during the activity.	
	NF3.2 S/he expresses her/his desire to use other materials to replace the open-ended materials presented to them.	
Explanation		

Appendix R: The Literature Review on Scaffolding Strategy

Scaffolding

The scaffold metaphor emerging as a result of efforts to define the interactions in the ZPD that bring about effective teaching/learning is closely related to ZPD. This viewpoint sees the child as a building that is actively building herself/himself. In this construction, the social context is a support system, called a scaffold, which enables the child to progress and build new abilities (Berk and Winsler, 1995). The emergence of the term of the *scaffolding* is based on this metaphor introduced by Wood, Bruner, and Ross (1976) who attempted to make explicit how adults support children in problem solving (Belland, Kim, & Hannafin, 2013) and identify the most significant elements of tutoring (Berk and Winsler, 1995). Although scaffolding is not a component of Vygotsky's theory and it is not possible to come across this term in his writings (Puntambekar & Hübscher, 2005), it is very compatible with the ZPD proposed by him (Schunk, 2011). Indeed, making possible for the learner to bridge the distance between his/her actual and potential is based on the conditions or the type of the support provided to him/her. From this aspect, the term scaffolding and ZPD fit each other (Puntambekar & Hübscher, 2005). Indeed, Vygotsky's theory and the concept of ZPD introduced by him underlies the scaffolding metaphor (Pentimonti, 2011).

As a teaching strategy, scaffolding means to provide the learners with support in a changing level in the direction of their needs (Kail, 2012; Santrock, 2011). In other words, scaffolding means how an adult promotes the child's development and education by presenting only the right support at only the right time and in only the right manner (Gillespie & Greenberg, 2017). Scaffolding makes it possible for the child to solve a problem and achieve a task or an objective which s/he would not achieve by means of his/her unassisted attempts (Wood et al., 1976). Indeed, scaffolding can be regarded as a bridge established by adults to provide a link between new knowledge with existing ones (Gillespie & Greenberg, 2017). Moreover, scaffolding is an ideal strategy for promoting children with a large variety of abilities by providing them with an ideal level of assistance (Pentimonti, 2011). In this process, when the child is faced with a task he has not learned before, the direct instruction may be utilized by the more competent person. As the child begins to gain competence in this task, the level of guidance is reduced (Santrock, 2011). In other words, once the competency is demonstrated by the child, the support provided by the scaffolding is removed from or gradually reduced to make sure that the competence is demonstrated and the knowledge is articulated by the child without any assistance (Lajoie, 2005). For instance, within the scope of a geometry course, a high school teacher scaffolds her/students by assisting them throughout each step while they experience to do proofs for the first time. As they begin to comprehend the way of doing proofs and achieve to do more individually, students need less assistance from their teacher. Therefore, the teacher reduces gradually her/his help (Kail, 2012). In this regard, an adult may call attention of the child to a forgotten situation or may be a model for the child to do a task or achieve a skill correctly by utilizing scaffolding (Bodrova & Leong, 2013). The dynamic system establishing between the learner and tutor in all these scaffolding processes and including the gradual progress of the learner is summarized in Figure 1.

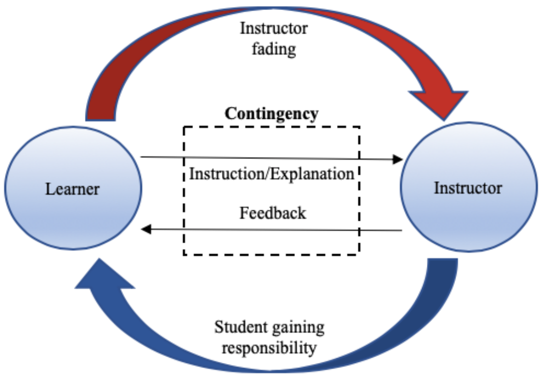


Figure 1 The dynamic interaction between the learner and instructor during scaffolding process (adapted from Malik (2017, p. 3)).

The scaffolding takes place in a variety of ways, such as giving a clue to the child, modeling the skill to be taught, or adapting learning activities and materials. It also can be offered in various contexts both in planned learning processes and in nonplanned experiences such as play, everyday routines, and outdoor experiences (NAEYC, 2009). During the scaffolding process, the interaction and collaboration which occur between the child and her/his teacher, parent or peer enable the child to construct new cognitive competencies (Berk & Winsler, 1995). For this reason, the method of scaffolding is very important in transferring skills from one to another. This transfer can take place in informal settings, such as in the home or play area, as well as in a formal setting such as the school (Kail, 2012). Indeed, each child's ZPD is different from each other, therefore, a higher level of support may be needed by some children while some require limited scaffolding for the same task. Hence, applying scaffolding strategies effectively depends on to what extent the scaffolder is knowledgeable about the child's competencies and the difficulty of the task, and to what extent s/he adapts her/his strategy accordingly (Pentimonti, 2011). The parents of the child are advantageous in the scaffolding as people who know their own children best (Evans, Moretti, Shaw, & Fox, 2003). Indeed, in the literature, a large body of research evidenced the positive effects of scaffolding provided by parents on their preschool children's education (Clegg & Legare, 2017; Neumann & Neumann, 2010; Skibbe, Behnke, & Justice, 2004; Sun & Rao, 2011).

Scaffolding includes adults using various verbal and non-verbal teaching techniques to determine existing skills in specific areas of development and challenge them to go beyond their existing levels of ability (MacNaughton & Williams, 2008). It is also crucial in terms of scaffolding in engineering education for preschool children. Indeed, parents can utilize the scaffolding as a way to support their children's learning and increase the active participation of their children in the task. In this way, the child can progress in small steps towards each goal and feel that they are emotionally supported in the learning process (Stone-MacDonald et al., 2015). On the other hand, all these abovementioned positive results can only be achieved by parents with an effective scaffolding. When it comes to the properties of an effective scaffolding, Berk and Winsler (1995) proposed following components and goals in the light of relevant literature.

- ***Joint problem solving:*** First of all, to achieve an effective scaffolding, children should be engaged in a problem-solving activity which is interesting for them and meaningful in terms of culture. This activity should be based on collaboration carried out between a child and an adult or a child and her/his peers. The important point is that the child interacts with the person the child collaborates with whom while trying to achieve the same goal together (Bers & Winsler, 1995). Therefore, some activities such as modelling a procedure, lecturing to the child, or instructing her/him concerning the procedure before being involved in solving the problems are not included in the scope of scaffolding. The support given only when the child is busy with a problem can be attributed to scaffolding (Belland, 2017).
- ***Intersubjectivity:*** Intersubjectivity means to the process through which two collaborators whose initial understandings are different from each other at the beginning of the task reached up a shared understanding. Indeed, a correct collaboration and an effective interaction during the course of joint activity can be achieved by working for the common goal (Berk & Winsler, 1995). At this point, intersubjectivity enables collaborators to develop a common point of view on how successful performance will look in the targeted task (Wertsch & Kazak, 2005). By means of this common understanding about the aim of the activity, the ownership of the work is shared, and the child develops a shared understanding with her/his partner about the goal that should be accomplished by him/her (Puntambekar &

Hübscher, 2005). Exhibiting intersubjectivity and being involved in the scaffolded performance enables the child to acquire the skill in the scaffolded performance and demonstrate that skill in the future independently (Belland, 2017) (see Figure 2).

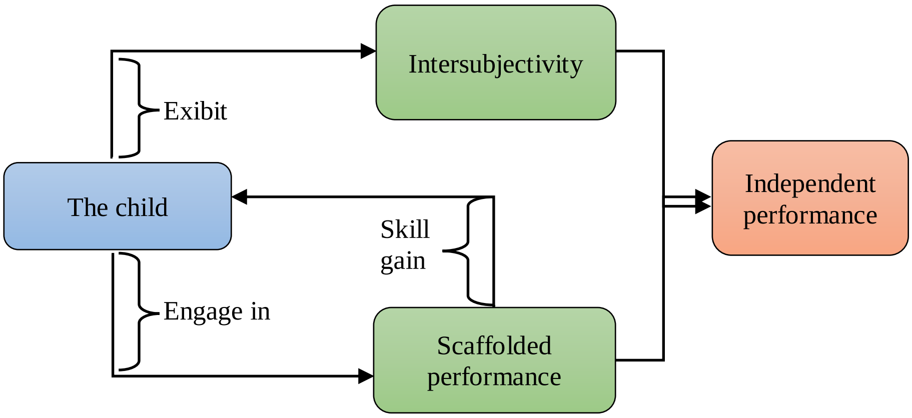


Figure 2 The role of the intersubjectivity in scaffolding process (adapted from Belland, 2017, p. 23).

- ***Warmth and responsiveness:*** Scaffolding contains social collaboration of the adult and the child to support the child's learning (MacNaughton & Williams, 2008). Indeed, a warm, responsive and pleasant collaboration and the verbal praises given by scaffolder make the child willing to challenge her/himself and to be engaged with the task in a maximum level. These verbal praises should attribute the child's abilities (e.g. "Now, you are getting it!", "Great! You did it."). The adult should consider what the child is saying and what s/he does, positively comment about the child's work and adhere closely to the needs of the child for additional support (MacNaughton & Williams, 2008). The scaffolding process can be regarded as a complex dance between the child and the adult, directed by the child and followed by the scaffolder for instructional goals. The success in this dance can be achieved by means of staying closely in concordance with the child's acts, attentively estimating the child's next step, and providing just enough assistance when the child needs it (Berk & Winsler, 1995, p. 29).
- ***Keeping children in their ZPD:*** The scaffolding mainly aims at ensuring that the child is involved in the tasks in her/his ZPD because the most intensive and effective learning of the child is possible when the child is working within his/her own ZPD (MacNaughton & Williams, 2008). Keeping the child in her/his own ZPD is possible in two ways. First of all, the learning environment and the task can be

structured by the adult implicitly or explicitly. In this way, the demands of the task can remain an appropriate challenging level for the child (Berk & Winsler, 1995). Indeed, the adult should ensure that the child's learning environment and learning experiences challenge him/her to “do” and think beyond her/his existing abilities when not supported by others. This includes fostering the child to try a new task or a new skill and use the equipment in new ways (MacNaughton & Williams, 2008). This also includes, for example, determining what options are available by the adult for the child's activities, and thus structuring activities. Similarly, a highly challenging task may be broken into smaller subtasks while an easy task may be made more challenging by adding new components or adding new rules to the activity (Berk & Winsler, 1995). In this way, it is possible for the child to meaningfully participate in the activity as possible and concentrate on the sub-phases of the problem solving that results in productive learning through scaffolding (Belland, Glazewski, & Richardson, 2011). Secondly, the adult should keep the child in her/his ZPD in the course of the collaborative activity by attentively adjust the level of the support (Berk & Winsler, 1995). It may be possible to provide appropriate assistance through a continuous diagnosis that focuses on the child's actual and potential level of abilities and performance. Indeed, in addition to having a complete knowledge about the task and the sub-goals that should be completed by the child, the adult should also have a complete knowledge about the child’s abilities which change in the course of the instruction process (Puntambekar & Hübscher, 2005).

- ***Fostering self-regulation:*** Children's self-regulation means that they control their own learning (MacNaughton & Williams, 2008). Scaffolding allows the child to organize the cooperative activity as far as possible. As a matter of fact, the support is faded when the child begins to work independently so that the child undertakes the responsibility of his own learning (Puntambekar & Hübscher, 2005). In other words, the adult should let the child struggle with the problems and should intervene in the process if the child is really stuck. In this way the child can remain in her/his zone of executive functioning in which the child has the responsibility of decision making and identifying joint activities and thus self-regulation is developed. On the other hand, constantly manipulating the behavior of the child by means of explicit commands, or giving her/him immediate answers when s/he is dealing with a momentary problem (“It is the orange one”, “Its place is here”) reduces the child’s not only learning but also self-regulation (Berk & Winsler, 1995).

Appendix S: Approval of the Human Subjects Ethics Committee

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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09 AĞUSTOS 2017

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Yrd. Doç. Dr. Hasibe Özlen DEMİRCAN ;

Danışmanlığını yaptığınız Aysun Ata AKTÜRK 'ün ***"Okul Öncesi Dönem Çocukları İçin Aile Katılımına dayanan Mühendislik Eğitimi Müfredatının Geliştirilmesi: Tasarım Temelli Bir Araştırma"*** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2017-EGT-138** protokol numarası ile **02.10.2017 – 08.06.2018** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Ş. Halil TURAN
Başkan V

Prof. Dr. Ayhan SOL
Üye

Prof. Dr. Ayhan Gürbüz DEMİR
Üye

Doç. Dr. Yaşar KONDAKÇI
Üye

Doç. Dr. Zana ÇITAK
Üye

Yrd. Doç. Dr. Pınar KAYGAN
Üye

Yrd. Doç. Dr. Emre SELÇUK
Üye

Appendix T: Approval of the Directorate of National Education

T.C.
KASTAMONU VALİLİĞİ
İl Millî Eğitim Müdürlüğü

Sayı : 75048956-44-E.19171592 — 14.11.2017

Konu : Anket İzni (Aysun ATA AKTÜRK)

KASTAMONU ÜNİVERSİTESİ REKTÖRLÜĞÜNE
(Öğrenci İşleri Daire Başkanlığı)

İlgi : 15/10/2017 tarih ve 16694033-302.08.01-E.8970 sayılı yazınız.

İlgi tarih ve sayılı yazınızda Üniversiteniz Eğitim Fakültesi Temel Eğitim Bölümü Okul Öncesi Eğitimi Ana Bilim Dalı Öğretim Elemanı Araş. Gör. Aysun ATA AKTÜRK'ün, "Okul Öncesi Dönem Çocukları İçin Aile Katılımına Dayanan Mühendislik Eğitimi Müfredatının Geliştirilmesi: Tasarım Temelli Bir Araştırma " başlıklı anket çalışması için hazırlamış olduğu uygulama ve veri toplama aşamalarını Müdürlüğümüze bağlı [redacted] öğrencileri ve velilerine 2017-2018 eğitim öğretim yılında gönüllülük esasına göre eğitim öğretim faaliyetlerini aksatmadan uygulanması ile ilgili Valilik Olur'u ilişikte gönderilmiştir.

Ekte gönderilen imzalı ve mühürlü anketin uygulanması hususunda;

Bilgilerinizi ve gereğini rica ederim.

Cengiz BAHÇACIOĞLU
İl Milli Eğitim Müdürü

Ek:

1- Valilik Olur'u (1 Sayfa)
2- Anket Çalışması (11 Sayfa)

T.C.
KASTAMONU VALİLİĞİ
İl Millî Eğitim Müdürlüğü

KASTAMONU 2018

Sayı : 75048956-44-E.13920264 30.07.2018
Konu : Anket İzni (Aysun ATA AKTÜRK)

Aysun ATA AKTÜRK
(Eğitim Fakültesi C Blok Kat 2 Merkez / KASTAMONU)

İlgi: 24/07/2018 tarihli ve 13690241 sayılı dilekçeniz.

İlgi tarih ve sayılı dilekçenize istinaden "Okul Öncesi Dönem Çocukları İçin Aile Katılımına Dayanan Mühendislik Eğitimi Müfredatının Geliştirilmesi: Tasarım Temelli Bir Araştırma" konulu anket çalışmasını Müdürlüğümüze bağlı [redacted] 2018-2019 eğitim öğretim yılında da gönüllük esasına göre kurumun eğitim-öğretim faaliyetlerini aksatmadan uygulaması ile ilgili Valilik Olur'u ilişikte gönderilmiştir.

Bilgilerinizi, imzalı ve mühürlü anketin uygulanması hususunda gereğini rica ederim.

Cengiz BAHÇACIOĞLU
İl Milli Eğitim Müdürü

Ek: Valilik Olur'u (1 sayfa)

Bayram DEMİRCİ 30 Temmuz 2018
V.H.K.İ.
Giden Evrak Yetkilisi

Appendix U. Curriculum Vitae

PERSONAL INFORMATION

Surname, Name: Ata Aktürk, Aysun
Nationality: Turkish (TC)
Date and Place of Birth: 12 December 1988, Kastamonu
Marital Status: Married
Phone: +90 534 741 02 27
email: aata@kastamonu.edu.tr

EDUCATION

Degree	Institution	Year of Graduation
MS	METU Elementary and Early Childhood Education	2015
BS	Kastamonu University Early Childhood Education	2011
High School	Kastamonu Kuzeykent High School	2006

WORK EXPERIENCE

Year	Place	Enrollment
2017-Present	Kastamonu University, Faculty of Education, Department of Early Childhood Education	Research Assistant
2013-2017	METU, Faculty of Education, Department of Early Childhood Education	Research Assistant
2011- 2012	Kastamonu 10 Aralık Vocational and Technical High School Practice Kindergarten	Preschool Teacher

PUBLICATIONS

Journal Papers

1. **Ata-Aktürk, A.**, & Demircan, H. Ö. (2016). Development of preschool children sibling rivalry scale (PSRS). Child Indicators Research, pp.1-20. DOI: 10.1007/s12187-016-9425-8.
2. **Ata-Aktürk, A.**, Demircan, H. Ö., Şenyurt, E., & Çetin, M. (2017). Turkish early childhood education curriculum from the perspective of STEM education: A document analysis. Journal of Turkish Science Education, 14(4), 16-34.

3. **Ata-Aktürk, A.**, & Demircan, H. Ö. (2017). Preschool teachers' teacher-child communication skills: The role of self-efficacy beliefs and some demographics. Journal of Education and Human Development, 6(3).
4. **Ata-Aktürk, A.**, & Demircan, H. Ö. (2017). A review of studies on STEM and STEAM education in early childhood. Journal of Kırşehir Education Faculty, 18(2), 757-776.

Conference Papers

1. **Ata-Aktürk, A.**, & Demircan, H. Ö. Draw an Engineer: Engineers and Engineering from Preschool Children's Viewpoint. X. International Congress of Educational Research (27-30 April, 2018, Nevşehir, Turkey).
2. **Ata-Aktürk, A.**, & Demircan, H. Ö. Engineering Related Aspects in Children's Picture Books. X. International Congress of Educational Research (27-30 April, 2018, Nevşehir, Turkey).
3. Çetin, M., **Ata-Aktürk, A.**, & Demircan, H. Ö. STEM Öğretmen Eğitiminin Okul Öncesi Eğitime Yansımalar: Bir Durum Çalışması. V. International Eurasian Educational Research Congress (EJER) (2-5 May, 2018, Ankara, Turkey).
4. Ubuz, B., Çetin, M., **Ata-Aktürk, A.** Cognitive Levels of the Tasks in Turkish Children Magazine: A Content Analysis. 18th. European Conference on Educational Research (ECER) (3-7 September, 2018, Bolzano, Italy).
5. Sevimli-Celik, S., & **Ata-Aktürk, A.** Nurturing Creativity and Playfulness in Early Childhood Pre-service Teacher Education. 27th. ICCP World Play Conference Researching Play-Challenges and Opportunities (15-17 June, 2017, Vilnius, Lithuania).
6. **Ata-Aktürk, A.**, & Demircan, H. Ö. Preschool Teacher Opinions on Integration of Art with STEM Disciplines in Preschool Classrooms. 5. International Early Childhood Education Congress (18-21 October, 2017, Ankara, Turkey).
7. Senyurt, E., Demircan, H. Ö., Cetin, M., & **Ata-Aktürk, A.** STEM (Science, Technology, Engineering, Mathematics) Education Approaches of Preschool Teachers. 5. International Early Childhood Education Congress (18-21 October, 2017, Ankara, Turkey).
8. Cetin, M., Demircan, H. Ö., Şenyurt, E., & **Ata-Aktürk, A.** STEM Teaching Intentions of Turkish Early Childhood Teachers. 69th OMEP World Assembly and International Conference (19-24 June, 2017, Croatia, Opatija).
9. **Ata, A.**, & Demircan, H.Ö. An Investigation of Preschool Teachers' Self-Efficacy Beliefs by Considering Some Demographics. VIII. International Congress of Educational Research (05-08 May, 2016, Canakkale, Turkey).
10. Demircan, H.Ö., **Ata, A**., Cetin, M., & Senyurt, E. Analysis of Early Childhood Education Curriculum in terms of STEM Education. III. International Eurasian Educational Research Congress (EJER), (31 May-3 June, 2016, Mugla, Turkey).
11. **Ata, A.**, & Demircan, H. Ö. Development of A Scale based on Parents' Reports to Measure Sibling Rivalry of Preschool Children. 16th. European Conference on Educational Research (ECER) (07-11 September, 2015, Budapest, Hungary).

Projects

1. Assistant Researcher, BAP Supported Research Project [BAPA], Science, Technology, Engineering and Mathematics (STEM) Education: Development of Training Kits, Teacher Education and Summer School Application, 2016-2017.

Appendix V: Turkish Summary / Türkçe Özet

OKUL ÖNCESİ EĞİTİMDE AİLE KATILIMLI STEM TEMELLİ BİR MÜHENDİSLİK TASARIM MÜFREDATININ GELİŞTİRİLMESİ

1. Giriş

İlk olarak Amerika Birleşik Devletleri'nde K-16 eğitimi için bir eğitim reformu olarak önerilen STEM (Bilim, Teknoloji, Mühendislik ve Matematik), çocukları mevcut yüzyılın küresel ekonomisine hazırlamayı amaçlayan bir eğitim yaklaşımıdır (Yakman ve Lee, 2012). Bu amaçla STEM, çocukların akademik başarılarını arttırmaya ve onları geleceğin işgücü için kritik bilgilerle donatmaya odaklanır (Quigley ve Herro, 2016). Çocuklara yaşam boyu öğrenmeyi sağlayan STEM eğitimi, onları gerçek hayattaki problemlerle meşgul eder ve araştırma tabanlı ve ilk elden öğrenme deneyimleri sunar. Bu bağlamda STEM eğitiminin gelecekteki sorunlarla başa çıkmanın ve yaşam kalitesini korumanın bir zorunluluğu olduğu görülmektedir (Van Meeteren ve Zan, 2010). Buna paralel olarak STEM eğitimini tüm eğitim seviyelerine entegre etmek ve geliştirmek, son yıllarda politika geliştiricilerin, araştırmacıların, eğitimcilerin ve ebeveynlerin odak noktası olmuştur (Carlisle ve Weaver, 2018; Dubosarsky, John, Anggoro, Wunnava ve Celik, 2018).

STEM kısaltmasını oluşturan disiplinlerden biri olan mühendislik, toplumun ihtiyaç ve beklentilerini göz önünde bulundurarak problemleri çözmeye, nesneleri ve sistemleri tasarlamaya odaklanır (Smetana, Schumaker, Goldfien ve Nelson, 2012). Mühendislik, bilim, teknoloji, matematik ve yaratıcılıktan yararlanarak insan sorunlarını sistematik bir şekilde çözmeye dayanır. Bu nedenle, tüm STEM disiplinlerinden çeşitli bilgi ve becerileri tek bir mühendislik faaliyetinde yoğurmak mümkündür (Stone-MacDonald, Wendell, Douglass ve Love, 2015). Başka bir deyişle, mühendislik, tüm STEM alanlarıyla (Bagiati ve Evangelou, 2015) ve ayrıca sanat ve edebiyat gibi diğer alanlarla (English, 2018) entegrasyon fırsatlarını geliştirme sözü verir.

Günümüz toplumu teknoloji ve mühendisliğe giderek daha fazla bağımlı hale geldikçe, mühendislerin yaptıkları işleri ve mühendisler tarafından üretilen teknolojilerin kullanım ve uygulama alanlarını herkesin bilmesi şarttır (Cunningham, 2009). Her ne kadar mühendislik sonuçları hayatımızın her yerinde mevcut olsa da birçok insan mühendisliğin ne olduğu ve mühendislerin ne ile uğraştıkları hakkında bilgi sahibi değildir. Öte yandan, ev aletlerinden oyuncaklara ve karmaşık sistemlere kadar uzanan teknolojilerin tamamı mühendislik ürünüdür. Bu bakımdan mühendislik, yüzyıllardır toplumları şekillendirmekte, dünyayı değiştirmekte ve toplumların yaşam kalitesini geliştirmektedir (Stone-MacDonald ve ark., 2015). Vaktimizin çok büyük bir bölümünü okul, çocuk parkları ve ev gibi insan yapımı alanlarda harcadığımız ve ayakkabılardan akıllı telefonlara kadar birçok insan yapımı ürünle etkileşimde bulunduğumuz günümüz dünyasında, çocuklara mühendislik bilgi ve becerilerini öğretmek ve mühendisliği takdir etmelerine yardımcı olmak için erken değildir (Davis, Cunningham ve Lachapelle, 2017). Aslında, yaşadığımız insanlık dünyasını anlamak, her insanın, küçük çocukların bile, mühendislik ve teknoloji bilgi ve becerilerinin geliştirilmesine bağlıdır (Cunningham, 2009).

Mühendislik eğitimi, çocuklara mühendislik tasarım sürecini deneyimleyerek pratik veya toplumsal öneme sahip sorunları çözme fırsatı sağlamayı ifade eder (National Academies of Science, Engineering, and Medicine, 2017). Bunun yanı sıra, mühendislik eğitimi, çocuklara günlük yaşamdan mühendislik örnekleri sağlamayı, çocukları farklı alanlarda çalışan mühendislerin ele aldıkları zorluklarla tanıştırmayı ve mühendisliğin yaşam kalitesini arttırmada değerini anlamasını içerir (Smetana ve ark., 2012). Bu açıdan mühendislik eğitimi, çocukların inşa edilmiş dünyayı anlamalarını sağlar (Cunningham, 2009). Bu noktada, erken çocukluk dönemindeki çocukların etraflarındaki dünyaya karşı doğuştan gelen merakları, soruların cevaplarını keşfetme ve inşa etme motivasyonları, bu dönemi mühendislik eğitimine başlamak için ideal bir zaman haline getirmektedir (Elkin, Sullivan ve Bers, 2018).

Okul öncesi çocuklar gelişmekte olan mühendislerdir. Öyle ki, çocuklar erken yaşlardan itibaren mühendislik tasarımında bir problemin belirlenmesi, çözüm üretilmesi, çeşitli çözümlerin en iyi çözümü ortaya çıkarmak için bunları inceleyerek karşılaştırılması gibi çeşitli problem çözme süreçleri için gerekli olan merkezi becerilerin çoğunu sergilerler (Bagiati ve Evangelou, 2011; Van Meeteren ve Zan, 2010). Doğuştan mühendisler olarak, küçük çocuklar nesneleri parçalara ayırır, sistemlerin nasıl çalıştığını büyük bir zevkle keşfeder ve kendi ürünlerini tasarlar (Cunningham, 2009). Bu noktada, mühendislik eğitimi, okul öncesi çocukların merakını ve ilgisini uyandırabilir ve çalışmalarını sürdürmeleri için onları motive edebilir. Bunun yanı sıra, mühendislikle uğraşmanın kazandırdığı perspektifler, çocukların mühendislik çalışmalarının dünyamızı derinden etkileyen yaratıcı bir girişim olduğunu anlamalarını sağlar. Bu şekilde, çocuklar bilim ve mühendisliğin değerini ve günümüz toplumlarının karşılaştığı birçok zorluğun üstesinden gelmedeki katkısını anlayabilecektir (ör. hastalıkların önlenmesi ve tedavisi, taze su ve gıda kaynaklarının korunması, yeterli enerjinin üretimi, iklim değişikliklerinin yönetimi) (Next Generation Science Standards [NGSS] Lead States, 2013).

Mühendislik eğitimi, okul öncesi dönem çocuklarına bilimsel kavramları gerçekçi ve ilgi çekici bağlamlarda sunmayı ve öğrenmeyi farklı içerik alanlarına entegre etmeyi sağlar (Moore ve diğ., 2018). Öyle ki mühendislik, çocukların sadece mühendisliğe yönelik içerikleri değil aynı zamanda diğer STEM disiplinlerine has kavramları da küçük yaşlardan itibaren somut bir şekilde deneyimlemelerini ve bu kavramları öğrenmelerini sağlar. (Hoisington ve Winokur, 2015). Aslında, matematik ve fenle ilgili fikirler, çocuklar tarafından daha karmaşık bir şekilde ve düşünüldüğünden daha genç bir yaşta soyutlanabilir ve genelleştirilebilir. Küçük çocuklar için bu karmaşık düşünme ve muhakeme yöntemi, erken mühendislik bilgi ve becerilerini desteklemenin yanı sıra, STEM'in diğer içerik alanları için bir temel sağlar (Moore ve ark. 2018).

STEM'in ve özellikle okul öncesi yıllardaki mühendislik eğitiminin çocukların problem çözme becerileri ve hem günlük yaşamlarında hem de okul yaşantılarında gelecekteki başarıları üzerindeki etkilerine dair umut verici kanıtlara rağmen (Dubosarsky ve ark., 2018), okul öncesi öğrenciler mühendislik ve teknoloji ile ilgili içeriklerle buluşma konusunda çok sınırlı bir fırsata sahiptir (Bagiati, 2011). Diğer bir deyişle, STEM'in kilit alanlarından biri olan mühendislik, çocukların mühendislik ve tasarım süreci hakkındaki farkındalıklarını ve ilgilerini artırmak için önemli ve biçimlendirici yıllar olan erken çocuklukta göz ardı edilme eğilimindedir (English, 2018). Son yıllarda yapılan araştırmalar mühendislik eğitimini okul öncesi eğitim ortamlarına getirmeye odaklansa ve bu araştırmalar aracılığıyla çocuklar mühendislik düşüncelerini, bilgi ve becerilerini geliştirme fırsatı bulsalar da, okul öncesi yıllara yönelik mühendislik eğitimi için geliştirilmiş standartlar henüz mevcut değildir (Bagiati, Yoon, Evangelou ve Ngambeki, 2010) ve okul öncesi dönem çocukları için geliştirilen, net bir öğretim felsefesi, öğrenme hedefleri ve değerlendirme araçları ile tanımlanmış mühendislik müfredatı sayısı oldukça sınırlıdır (Bagiati, 2011; Dubosarsky ve diğerleri, 2018). Benzer şekilde, mühendislik ve teknoloji disiplinlerine mevcut okul öncesi eğitim müfredatımızda da (Millî Eğitim Bakanlığı [MEB], 2013) oldukça sınırlı bir yer verilmiştir (Ata-Aktürk, Demircan, Senyurt ve Çetin, 2017).

Kapsamlı bir müfredat, öğretmenlerin ve diğer eğitimcilerin neyi nasıl öğretecekleri hakkında dikkatlice karar vermeleri için kilit bir noktadır. Böyle bir müfredat, çocuk gelişiminin tüm boyutlarını ele almak ve ailelerle ortaklıklar kurmak için bir program planlamak ve uygulamak için gereken planı sunar (Dodge, 2004). Bronfenbrenner'ın vurguladığı gibi, çocuk farklı katmanlardan oluşan karmaşık bir sistemde büyür ve bu sistemin merkezinde yer alır (Berk, 2013). Hem aile hem de okul, çocuğun yakın çevresinin önemli bileşenleridir (Hayes, O'toole ve Halpenny, 2017) ve Papert'in savunduğu gibi, çocuğun bu iki bileşen tarafından sağlanan öğrenme fırsatlarına ihtiyacı vardır (Ackerman, 2001).

Nitekim, ebeveynler ve eğitimciler çocukların mikrosisteminde en düzenli ve en sık bulunan kişiler olduğundan, çocuklara sundukları öğrenme fırsatları aracılığıyla okul öncesi çocukların STEM öğreniminde etkilidirler (McClure ve ark., 2017). Bu nedenle, erken çocukluk sınıflarında, mühendislik içeriğiyle uyumlu başarılı bir müfredat yeniliği, birden fazla paydaşın sürece dahil edilmesini gerektirir (Bagiati ve Evangelou, 2015). Başka bir deyişle, mühendislik ve teknoloji disiplininin ne olduğunu ve neden hem insanlar için hem de dünya için önemli olduklarını anlayan bir neslin yetiştirilmesi, öğretmen, veli ve çocukların dahil oldukları uygulama topluluklarının enerjilerini, yaratıcılıklarını ve yeteneklerini zorunlu kılmaktadır (Cunningham, 2009). Bu nedenle, diğer tüm disiplinlerde olduğu gibi, ebeveynlerin eğitim sürecine dahil edilmesi okul öncesi çocuklara yönelik mühendislik eğitimi girişimleri için oldukça büyük bir öneme sahiptir (Bagiati ve Evangelou, 2015; Dorie ve Cardella, 2014; Smetana ve diğerleri, 2012).

Okul öncesi öğretmenleri, çocukların merakını uyandıran ve düşünme becerilerini geliştiren öğrenme deneyimleri tasarlayabilirler. Ayrıca, günlük çalışmalarında problem çözme becerilerini kullanarak, çocuklar için model olma fırsatlarını arayabilir ve bu nedenle okul öncesi çocukları genç problem çözücüler olarak teşvik eden ve besleyen bir sınıf ortamı yaratabilirler (Stone-MacDonald ve diğ., 2015). Ancak, okul öncesi dönem çocukları okul dışından çeşitli dış ve iç kaynaklar aracılığıyla öğrenmeye devam etmektedir. Okul dışında meydana gelen bu yaygın öğrenme deneyimleri, sınıf öğretimi kadar etkili olabilir (Dorie ve Cardella, 2014). Bu nedenle, sınıf ortamında çocuklara verilen mühendislik eğitimi okul dışındaki ortamlarda ebeveynleri tarafından desteklendiğinde olumlu sonuçlar almak mümkündür. Öyle ki, ebeveynler çocuklarının mühendisliğe yönelik merakını motive edebilir, çocuklarına mühendislik kavramları ve yeterlilikleri konusunda deneyimler sağlayabilir ve meslekleri mühendislik olan ebeveynler çocuklarına rol model olabilir (Dorie, Jones ve Pollock, 2014). Öte yandan, araştırmalar, mühendisliğin eğitimciler ve veliler tarafından STEM'in diğer alanlarına kıyasla daha korkutucu ve ulaşılamaz olarak algılandığını ortaya koydu (Stone-MacDonald ve ark., 2015). Öyle ki, mühendislik geçmişine sahip olmayan öğretmenler ve veliler, mühendisliği genel olarak uzmanlık gerektiren bir içerik olarak algılamaktadırlar. Bu durum ebeveynlere ve küçük çocukların eğitimcilerine yönelik mühendislik eğitimi için sınırlı sayıda kaynağın bulunmasıyla ilgili olabilir (Bagiati ve diğerleri, 2010; Bagiati ve Evangelou, 2018). Aslında, erken çocukluk eğitim programlarında köklü bir geçmişi olan bilim ve matematik disiplinlerinin aksine, mühendislik yeni bir bilgi tabanıdır. Bu nedenle, mühendisliğin ilk yıllarda nasıl öğretilmesi gerektiği (hem okulda hem de ev ortamında) ya da ne tür materyaller ve nasıl bir müfredatın kullanılması gerektiği gibi çok sayıda temel soru cevapsız kalmıştır (Katehi ve ark., 2009). Bu tür soruların yanıtlarını bulmak için, erken çocukluk dönemi için geliştirilen araştırma tabanlı bir mühendislik müfredatına ihtiyaç vardır (English, 2018). Ayrıca, bu tür müfredat yenilikleri ebeveynlere, öğretmenlere ve çocuklara mühendislik ve STEM'i birlikte deneyimleme ve öğrenme fırsatı vermelidir (Akgündüz, Ertepınar, Ger, Türk, 2018; McClure ve diğerleri, 2017). Bu çalışma hem teoride hem de uygulama mevcut olan bu ihtiyacı karşılamak üzere okul öncesi çocuklar için gelişimsel olarak uygun ve aile katılımlı STEM temelli bir mühendislik müfredatı (EDCPI) tasarlanması ve geliştirilmesini hedeflemektedir. Mevcut çalışma aynı zamanda bu tür bir müfredatın tasarlanması ve geliştirilmesindeki temel tasarım ilkelerini keşfetmeyi amaçlamıştır. Bu bağlamda, bu çalışma, tasarlanan ve geliştirilen müfredatın temel özelliklerini ve katılımcıların bakış açılarından müfredatın engelleyici ve kolaylaştırıcılarını belirlemeyi amaçlamaktadır. Çalışma aynı zamanda, geliştirilen müfredatın okul öncesi çocuklar, ebeveynler ve öğretmenlere katkılarının araştırılmasını hedeflemektedir. Bu amaçlar doğrultusunda aşağıdaki araştırma sorularına cevap aranmıştır:

1) Okul öncesi çocuklar ve ebeveynlerine mühendislik alanında öğrenmeler sağlamayı amaçlayan bir mühendislik müfredatı nasıl tasarlanabilir ve geliştirilebilir?
   a) Okul öncesi çocukların ebeveynleriyle mühendisliği deneyimleme fırsatı sunan ve onlara mühendislik ve STEM'de öğrenmeler sağlayan etkili bir mühendislik müfredatının temel özellikleri nelerdir?
   b) EDCPI'nın kolaylaştırıcıları nelerdir?
   c) EDCPI'nın önündeki engeller nelerdir?

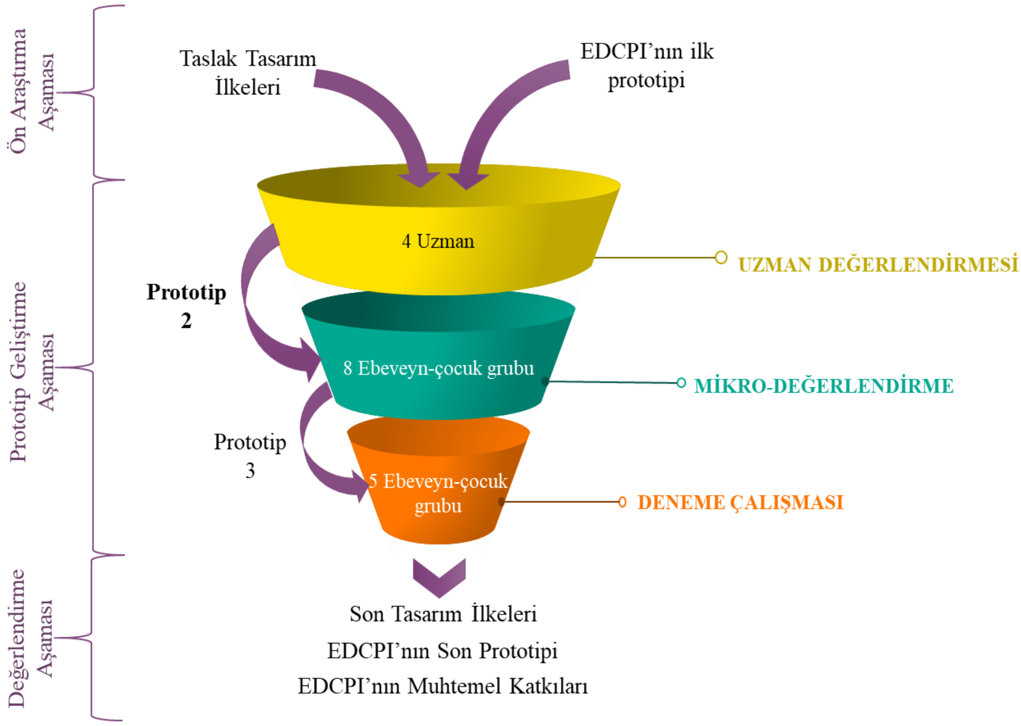
2) EDCPI'nın hedef kullanıcılarına olası katkıları nelerdir?
   a) EDCPI'nın okul öncesi çocuklara olası katkıları nelerdir?
   b) EDCPI'nın ebeveynlere olası katkıları nelerdir?
   c) EDCPI'nın okul öncesi öğretmenlerine olası katkıları nelerdir?

2. Yöntem

Çalışmanın amaçları ve doğası göz önünde bulundurularak, mevcut çalışmada EDCPI'nın tasarlanması, geliştirilmesi ve temel özelliklerinin belirlenmesi için tasarım tabanlı araştırma yöntemi kullanılmıştır. Tasarım tabanlı araştırma yöntemi, doğası gereği, karmaşık eğitim uygulamalarına yönelik araştırma tabanlı çözümler tasarlamayı ve geliştirmeyi ya da eğitim teorileri geliştirmeyi veya doğrulamayı amaçlamaktadır. Bu nedenle, bu yöntemde araştırma süreci, bir ihtiyaç veya sorunun tanımlanması ile başlayan ve bir çözümün üretilmesiyle sona eren bazı sistematik tasarım adımlarını (Design-based Research Collective, 2003) içerir. Nitekim, tasarım tabanlı araştırma yöntemi analiz, tasarım ve prototip geliştirme, değerlendirme ve revizyon gibi bazı aktiviteleri içeren yinelemeli bir döngü içerir. Bu yineleme süreci, idealler ve gerçekleşmeler arasında öngörülen dengeye ulaşılıncaya kadar devam eder (Plomp, 2013). Tasarım tabanlı uygulamalar nadiren mükemmel şekilde tasarlanır ve uygulanır. Bu nedenle, tasarımda ve takip eden değerlendirmede daima gelişim için yer vardır (Anderson ve Shattuck, 2012). Yeni bir müfredat tasarlamayı amaçlayan bu çalışmada, tasarlanan bu müfredatı çeşitli döngüler sırasında toplanan veriler ışığında geliştirmek ve bu müfredatın temel özelliklerini ve bu müfredatı engelleyen ve kolaylaştıran faktörleri araştırmak amacıyla birçok yinelemenin yapılması önemliydi. Bu bağlamda, tasarım tabanlı araştırma yöntemi mevcut çalışmanın amaçları ile paralellik göstermektedir. Bunun yanı sıra, tasarım tabanlı araştırma yöntemi ayrıca eğitim araştırmacılarına, pratik ve etkili müdahaleler üretmek ve tasarıma rehberlik etmek için bir teori üretmek amacıyla araştırmacıların gerçek dünyadaki sorunlara yönelik müdahaleleri tasarladığı ve incelediği bir süreç sunmaktadır (Easterday, Rees Lewis ve Gerber, 2014). Bu yönüyle, eğitim ortamlarında tasarım tabanlı çalışmalar teori ve gerçek sınıf uygulamaları arasında köprü kurmaya katkıda bulunma potansiyeline sahiptir (van den Akker ve ark., 2013). Bu nedenle, okul öncesi çocuklar için mühendislik eğitimi fırsatlarına ihtiyaç duyulduğunu düşünerek aile katılımlı ve STEM temelli bir mühendislik müfredatı geliştirmeyi amaçlayan bu çalışma, faydalı ve teoriye dayalı bir eğitim ürünü tasarlamak ve onu pratikte geliştirmek konusunda tasarım tabanlı araştırma yönteminin amaçları ile örtüşmektedir (Collins, 2004).

2.1 Araştırma Evreleri

Bu çalışmada, müfredat tasarımı ve geliştirme sürecinde üç aşamalı bir süreç izlenmiştir (bkz. Şekil 1). İlk olarak, ön araştırma aşaması kapsamında, ilgili alan yazın gözden geçirilmiş ve EDCPI'nın ilk tasarım ilkelerini belirlemek amacıyla temel bilgileri elde etmek için bağlam analizi yapılmıştır. İkinci olarak, prototip geliştirme aşamasında, müdahalenin prototipleri biçimlendirici değerlendirme kullanılarak yinelenerek geliştirilmiş ve revize edilmiştir. Biçimlendirici değerlendirmenin tüm aşamaları boyunca, EDCPI'nın prototipleri ve tasarım ilkeleri revize edilmiş ve yeniden şekillendirilmiştir. Son olarak, özetleyici değerlendirme aşamasında (Mafumiko, 2006; Wang ve diğerleri, 2014) odak noktası EDCPI'nın etkinliğini değerlendirmekti. Diğer bir deyişle, müfredatın amaçlanan hedeflere ulaşmayı ne ölçüde sağladığının belirlenmesi, son aşamada amaç olmuştur (Thijs & van den Akker, 2009). Öte yandan, bu çalışmada EDCPI'nın gerçek uygulanabilirliği veya etkinliği incelenememiştir. Deneme çalışması tamamlandıktan sonra, EDCPI'nın son bir prototipi ortaya çıkmış ve bu son prototip uzman değerlendirmesi yoluyla biçimlendirici olarak değerlendirilmiş ancak eğitim ortamında tekrar uygulanmamıştır.



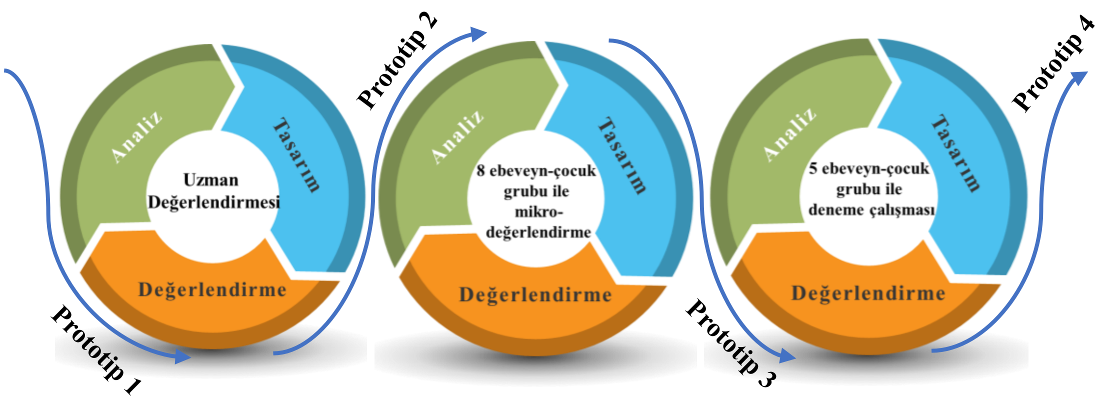
Şekil 1 Mevcut tasarım tabanlı araştırmanın evreleri.

2.1.1 Aşama I: Ön Araştırma Evresi

Ön araştırmalar açısından, bu çalışmada, ilk adım olarak ihtiyaç ve bağlam analizleri yapılmıştır. Bu analizler araştırmacıya, böyle bir müfredatın gerekliliğini ve çocuklarının STEM eğitimi sürecinde ebeveynlere duyulan ihtiyacın belirlemesini sağlamıştır. İhtiyaç analizi, okul öncesi öğretmenlerinin kendilerini STEM yaklaşımı konusunda yetersiz gördüklerini ortaya koymuştur. Nitekim, okul öncesi öğretmenleri, ebeveynlerin çocukların STEM eğitim sürecine katılımına (Park ve diğ., 2017) ve STEM eğitimi sürecinde onlara rehberlik etmek için örnek bir müfredata ihtiyaç duyduklarını ifade etmişlerdir (Ata-Aktürk ve Demircan, 2017). Bu nedenle, okul öncesi çocuklar için STEM temelli, ebeveynleri de öğrenme sürecine dahil eden ve ampirik kanıtlara dayalı örnek bir mühendislik müfredatı tasarlama ve geliştirme kararı alınmıştır. Benzer şekilde, bağlam analizi, erken çocukluk eğitiminde mevcut mühendislik durumunun profilini netleştirmiş ve böyle bir mühendislik müfredatının geliştirilmesine ilişkin kararı desteklemiştir. Mevcut okul öncesi eğitim müfredatının (MEB, 2013) STEM'in entegrasyonuna uygun olmasına rağmen, fen, matematik ve teknolojiyi birleştiren mühendislik faaliyetlerini örneklemesi gerektiği bulunmuştur (Ata-Aktürk ve diğ., 2017). Bağlam analizi dahilinde ayrıca ilgili alan yazın gözden geçirilmiş ve bu inceleme araştırmacıya STEM, mühendislik ve aile katılımı alanlarındaki güncel uygulamalar hakkında bilgi sağlamıştır (Bagiati, 2011; Bagiati ve Evangelou, 2015; Cunningham ve Lachapelle ve Davis, 2018; English, 2018; Pantoya ve diğ., 2015; Sullivan ve diğ., 2015; Van-Meeteren ve Zan, 2010). Alan yazın taraması ayrıca, araştırmacının benzer amaçlar için geliştirilen mevcut müfredat örneklerini ve müfredatın hedef kullanıcılarının ihtiyaçlarını ve sorunlarını belirlemek için var olan vaka çalışmalarını analiz etmesini sağlamıştır (van den Akker, 2013). Bu bağlamda, ilgili alan yazının gözden geçirilmesi, EDCPI'nın okul öncesi çocukların öğrenmelerine katkıda bulunabilecek ve aile katılımı yoluyla erken mühendislik eğitimini destekleyebilecek potansiyel faydalarını netleştirmiştir.

2.1.2 Aşama II: Prototip Geliştirme Evresi

Prototip geliştirme, tasarım ürünlerinin gerçek yaşam problemlerini çözmek için sistematik bir süreçte değerlendirilmesi ve revizyonunu ifade eder (van den Akker ve ark. 2006). Bu çalışmanın prototip geliştirme aşamasında, uzmanlardan alınan geri bildirimler, tasarım destek ekibi ve öğretmenlerle ortak çalışmalar ve yinelemeli uygulamalardan elde edilen bulgular müdahalenin gelişmesine katkıda bulunmuştur. Alt bölümler, prototip geliştirme sürecinde gerçekleştirilen bu mikro fazların her biri, her mikro aşamada araştırmacı tarafından takip edilen prosedürler ve EDCPI'nın pratiklik ve etkinlik konularının belirlenmesi hakkında bilgi sunar (bkz. Şekil 2).



Şekil 2 Çalışmada izlenen biçimlendirici değerlendirme sürecinin yinelemeleri.

2.1.2.1 Birinci Evre: Uzman Değerlendirmesi

EDCPI'nın taslak versiyonu taslak tasarım ilkeleri ve ön aşamada elde edilen bulgular doğrultusunda tasarlanmıştır. Böylelikle, bu taslak tasarımın prototipler boyunca rafine edilmesini ve geliştirilmesini sağlayacak olan EDCPI'nın yineleme süreci başlatılmıştır

(Wang ve diğ., 2014). İlk adım olarak, uygulama sonunda müfredat aracılığıyla okul öncesi çocuklar tarafından edinilmesi beklenen bilgi ve becerileri tanımlayan öğrenme hedefleri belirlenmiştir (Dick ve diğ., 2015). Bu noktada mühendislikle ilgili mevcut çerçeveler (Lottero-Perdue ve ark., 2016; Katehi ve diğ., 2009; NGSS Lead States, 2013; NRC, 2012; Stone-MacDonald ve diğ., 2015) ve okul öncesi, anaokulu ve ilkokul çocuklarına yönelik müfredatlar (Bagiati, 2011; Cunningham, 2009) araştırmacıya rehberlik etmiştir. Öte yandan, bu müdahalenin ebeveynlerin yanı sıra çocuklar için de bazı katkıları olabileceği düşünülmüştür. Bu nedenle, EDCPI'nın öğrenme hedefleri ve göstergeleri ebeveyn ve çocukla ilgili öğrenme hedefleri olmak üzere iki boyutta oluşturulmuştur. Çocuklarla ilgili öğrenme hedeflerinde olduğu gibi, ebeveynlerle ilgili öğrenme hedefleri, ilgili alan yazın kılavuzluğunda tanımlanmıştır (Dorie ve Cardella, 2014; Dorie ve diğ., 2014; Ihmeideh ve Oliemat, 2015; Smetana ve diğ., 2012). Araştırmacı ve tasarım destek ekibinden bir başka araştırmacı bu taslağı inceledikten sonra, EDCPI öğrenme hedefleri iki uzman tarafından değerlendirilmiş ve geri bildirim sağlanmıştır. Bu iki uzmandan alınan geri bildirimlere dayanarak, EDCPI öğrenme hedefleri geliştirilmiştir ve bu öğrenme hedefleri temel alınarak taslak tasarım ilkeleri, müfredat aktiviteleri ve EDCPI'nın diğer bileşenleri (öğretmenlerin ve velilerin bu faaliyetlerdeki rolü, öğrenme süreci) tasarlanmıştır. Bir sonraki adım olarak ise, tasarlanan tüm bu içerik dört uzmanın değerlendirmesine sunulmuştur. EDCPI içeriği ile ilgili uzmanların yorumları alındıktan sonra, bu yorum ve öneriler ışığında ilk prototipte revizyonlar yapılmıştır. Sadece uygulayıcılarla değil, uzmanlarla da iş birliği yapmak, müfredatın geliştirilmesine katkıda bulunmuş ve içeriğe dayalı sorunları çözmek için daha uygun adımlar geliştirilmesine yardımcı olmuştur (Cobb ve diğ. 2003). Bu nedenle, uzman değerlendirmesi ışığında ilk prototipin revizyonu ile prototip oluşturma aşamasında biçimlendirici değerlendirme döngüleri başlatılmıştır ve ilk döngü ikinci prototipi ortaya çıkarmıştır (Mafumiko, 2006).

2.1.2.2 İkinci Evre: Mikro-değerlendirme Çalışması

Bu tasarım tabanlı araştırmada prototiplerin biçimlendirici değerlendirme süreci, uzmanların geri bildirimleri doğrultusunda geliştirilen ikinci prototipin mikro-değerlendirme çalışması ile sürdürülmüştür. Mikro-değerlendirme çalışmasının amacı, EDCPI'nın ECE ortamlarındaki geçerliliğini ve beklenen uygulanabilirliğini araştırmak ve bu ilk uygulamadan elde edilen veriler doğrultusunda EDCPI'yı iyileştirmektir. Mikro-değerlendirme çalışması, 2017-2018 eğitim-öğretim yılının bahar döneminde, bir devlet okulunda çalışan bir okul öncesi öğretmeni (T1), bu okul öncesi öğretmenin sınıfındaki sekiz çocuk ve bu çocukların ebeveynleri ile yapılmıştır. T1 mühendisliği erken çocukluk sınıflarına nasıl entegre edeceğini öğrenmek için oldukça istekliydi. Buna ek olarak, eğitim alanında yüksek lisans öğrencisiydi ve kendi yüksek lisans tezini yürüttüğünden bilimsel araştırmanın nasıl yapılacağı konusunda deneyime sahipti. Öğretmen otuz altı yaşındaydı ve okul öncesi öğretmenliği bölümünden lisans derecesine sahipti. Çalışmanın yapıldığı sömestrde, T1 on yedi yıllık öğretmenlik deneyimine sahipti ve sınıfında 60 ila 74 aylık yirmi öğrenci vardı. Öğretmen daha önce böyle bir uygulamaya katılmamış ve STEM eğitimi konusunda herhangi bir eğitim almamıştı.

Katılımcı okul ve öğretmen belirlendikten sonra, bu öğretmenin sınıfındaki çocukların ebeveynleri, ebeveyn izin formu aracılığıyla çalışma hakkında bilgilendirilmiştir (bkz. Ek M). Bu şekilde, gönüllü ebeveynler ve çalışmaya katılacak olan çocuklar tespit edilmiştir. İkinci prototip T1 tarafından üç cumartesi günü (10:30-13:30 arasında) uygulanmış ve son iki öğrenme etkinliği, Perşembe ve cuma akşamları (17:00-20:00 arasında) gerçekleştirilmiştir. Başka bir deyişle, mikro-değerlendirme çalışması toplamda 4 hafta sürmüş ve her birinde EDCPI'nın farklı bir öğrenme aktivitesinin uygulandığı beş oturumda gerçekleştirilmiştir.

Mikro-değerlendirme çalışması, çalışmanın yapıldığı kentteki araştırma izni prosedürlerinden dolayı katılımcı öğretmenin kendi sınıf ortamında değil, araştırmacının çalıştığı fakültedeki uygun bir salonda gerçekleştirilmiştir. Araştırmacı toplam 1050 dakikalık video ve ses kaydı yapmış ve bunları çocuk gözlem formları aracılığıyla analiz etmiştir. İki lisans öğrencisi, araştırmacının etkinlik öncesi öğrenme ortamını hazırlamasına ve etkinlik uygulaması sırasında fotoğraf çekmesine yardımcı olmuştur. Bu öğrenciler ilk aktiviteye başlamadan önce hem çocuklara hem de ebeveynlere tanıtılmış ve neden orada bulundukları açıklanmıştır.

2.1.2.3 Üçüncü Evre: Deneme Çalışması

Nieveen ve Folmer'in (2013) vurguladığı gibi, her prototip, tasarım araştırmacısına daha sağlam bir temel ve karmaşık bir eğitim sorununu çözmek amacıyla üzerinde çalıştığı nihai ürün için argümanlar sunar. Benzer şekilde, bu çalışmada, ikinci prototipin mikro-değerlendirmesinin bulguları üçüncü prototipin tasarımına ışık tutmuş ve mikro-değerlendirme çalışmasının bulguları, tasarım destek ekibi ile değerlendirilmiştir. EDCPI'nın ikinci prototipi mikro-değerlendirme bulguları doğrultusunda revize edilerek üçüncü prototip yaratılmıştır. Üçüncü prototipin denenmesi, EDCPI'nın pratikliğini ve etkinliğini araştırmak için müfredatın hedef kullanıcılarının küçük bir örneği ile gerçekleştirilmiştir. Üçüncü prototipin denemesi 2018-2019 eğitim-öğretim yılının güz döneminde yapılmıştır. Deneme çalışması, mikro-değerlendirmenin yapıldığı şehirde (Kastamonu) yapılmış, ancak bu kez araştırmacı, şehir merkezinde 36 ila 72 ay arası çocuklara hitap eden başka bir okul öncesi eğitim kurumuyla çalışmıştır. Deneme çalışmasının katılımcıları, bu kurumda çalışan iki okul öncesi öğretmeni (T2 ve T3), bu öğretmenlerin sınıflarından toplam beş çocuk ve bu beş çocuğun velilerinden oluşmaktaydı. Bu iki öğretmenin sınıfındaki beş gönüllü ebeveyn-çocuk grubu bir sınıfta bir araya getirilmiş ve uygulamalar aynı eğitim ortamında bu iki öğretmen tarafından gerçekleştirilmiştir. Müfredat etkinliklerinin üçü T2, ikisi ise T3 tarafından uygulanmıştır. Ancak, her iki öğretmen de beş aktivite şablonunu da okumuş ve aktiviteler hakkında geribildirim vermek için araştırmacıyla toplantılara katılmışlardır. T2 otuz sekiz yaşındaydı ve yaşları 3-6 arasında değişen farklı yaş gruplarındaki çocuklarla on sekiz yıllık mesleki deneyime sahipti. Okul öncesi öğretmenliği alanında lisans derecesine sahipti. MEB tarafından sağlanan drama, müzik ve sanat eğitimi ile ilgili çeşitli hizmet içi eğitimlere katılmıştı. Ancak, STEM veya mühendislik eğitimi konusunda hiçbir deneyimi veya eğitimi yoktu. Bu çalışmanın yapıldığı sırada T2, 5-6 yaşları arasında 18 çocukla çalışıyordu. T3 ise otuz iki yaşındaydı ve farklı gruplardan çocuklarla (3-6 yaş) sekiz yıllık mesleki deneyime sahipti. Okul öncesi eğitimi alanında lisans derecesine sahipti. Mevcut çalışmadan önce herhangi bir hizmet içi eğitime ya da böyle bir akademik çalışmaya hiç katılmamıştı ve STEM eğitimine yönelik herhangi bir deneyimi yoktu. Bu çalışma yapıldığı sırada, T3 sınıfında 5-6 yaşları arasında 17 çocuk vardı.

Deneme çalışması ilk üç hafta boyunca cumartesi günleri yapılmıştır. Ancak dördüncü haftada dördüncü etkinlik cumartesi günü, beşinci etkinlik pazar günü gerçekleştirilmiştir Faaliyetler 13:00-16:00 saatleri arasında yapılmıştır. Bu şekilde, EDCPI'nın üçüncü prototipi dört haftalık bir süreçte denenmiştir. Mikro-değerlendirme bulguları ışığında, üçüncü prototipin deneme çalışması gerçek bir okul öncesi sınıfında gerçekleştirilmiştir. Bu bağlamda, uygulamanın hafta sonları yapıldığı anaokulunun uygun bir sınıfını kullanmak için fakülteden gerekli izinler alınmıştır. Böylece, EDCPI gerçek bir okul öncesi sınıf ortamında denenmiştir. Uygulama sırasında, kısa molalara ek olarak (beş dakika), problemi çocuklara sunma adımından sonra (planlama aşamasına geçmeden önce) yarım saatlik bir mola verilmiştir. Bu şekilde, her bir etkinlik, yaklaşık üç saat süren toplam beş oturumda tamamlanmıştır. Mikro-değerlendirmede olduğu gibi, bu süreçte de araştırmacı gözlemlerde bulunmuştur ve sınıfta neler olduğu hakkında saha notları tutmuştur. Ayrıca, her oturumda, uygulama süreci ses ve video kaydediciler aracılığıyla kaydedilmiştir.

2.1.3 Aşama III: Değerlendirme Evresi

Değerlendirme aşaması, prototip geliştirme aşamasında geliştirilen müdahalenin uygulamadaki etkinliğinin kanıtını elde etmek ve çalışmayı sürdürme veya bitirme kararını destekleyen argümanlar sunmak için bir özet değerlendirme içerir (Nieveen ve Folmer, 2013; Plomp, 2010). Deneme çalışması tamamlandıktan sonra, bulgular ve uzman görüşleri ışığında

EDCPI'nın üçüncü prototipi revize edildi ve böylece son prototip oluşturuldu. Bu son prototip için herhangi bir deneme çalışması yapılmadığından, EDCPI'nın bu son formu değerlendirme aşamasında beklenen pratikliği ve etkinliği açısından değerlendirilmiştir. Bu bağlamda, EDCPI hedef kullanıcıları olan öğretmenler ve ebeveynler tarafından kullanılıp kullanılamayacağı (pratiklik) ve bunu kendi öğretimlerinde uygulamaya istekli olup olmayacakları (uygunluk ve sürdürülebilirlik) açısından değerlendirilmiştir (Plomp, 2010). Bu kriterlere ek olarak, EDCPI önceden belirlenmiş öğrenme hedeflerine ulaşılıp ulaşılmadığı ve müfredatın hedef kullanıcıları olan çocuklar, ebeveynler ve öğretmenlere olası katkılarının (etkinlik) neler olduğu konusunda değerlendirilmiştir.

3.1 Veri Toplama Araçları

Tasarım tabanlı araştırma, tasarım amaçlarının değerlendirilmesi ve tasarım sürecinin iyileştirilmesi için çeşitli araştırma teknikleri aracılığıyla çeşitli veri toplama araçlarından yararlanılmasını sağlar (Anderson ve Shattuck, 2012). Öte yandan, tasarım tabanlı araştırmanın gerçekleştirildiği bir öğrenme ortamında, birçok kontrolsüz değişken sürece dahil olmaktadır. Bu nedenle tasarım araştırmacıları, tasarımı mümkün olduğunca optimize etmek ve çeşitli bileşenlerin nasıl çalıştığı hakkında dikkatli gözlemler yapmak için çaba harcarlar (Collins ve ark. 2004). Benzer şekilde, bu çalışmada, görüşmeler, çocuk gözlem formu, çocuk portföyleri, öğretmen ve araştırmacıların saha notları, haftalık dergiler ve ses ve video kayıtları gibi birden fazla nitel ve nicel veri kaynağı kullanılarak üçgenleme stratejileri kullanılmıştır. Veri kaynaklarının üçgenleştirilmesi araştırmacıya katılımcılardan elde edilen verilerin analizi ve yorumlanmasında öğretmenler, ebeveynler ve okul öncesi çocuklar açısından bütüncül bir bakış açısı sağlamıştır.

Hem mikro değerlendirme hem de deneme çalışmasında aynı veri toplama araçları kullanılmıştır. Ancak, mikro-değerlendirme, ebeveyn ve öğretmen görüşmeleri ve çocuk gözlem formunda bir sonraki uygulamadan önce gözden geçirilmesi gereken bazı hususları ortaya koymuştur. Bu nedenle, deneme çalışmasından önce, bazı veri toplama araçlarında gerekli değişiklikler yapılmıştır ve bu değişiklikler konusunda uzmanlara danışılmıştır. Ayrıca, deneme çalışmasında mikro değerlendirmeden farklı olarak veri toplama araçları arasına günlükler eklenmiştir. Aşağıdaki alt bölümlerde, bu çalışmada kullanılan tüm bu veri kaynakları hakkında bilgi verilmektedir.

3.2 Veri Analizi

Bu çalışmada veriler daha çok nitel tekniklerle toplanmıştır. Veri analizi sürecinin başında, bu çalışma için en uygun veri analizi yöntemini belirlemek için ilgili literatür gözden geçirilmiştir. Çalışmanın nitel verilerini analiz etmek için Glaser ve Strauss (1965) tarafından önerilen ve tasarım tabanlı araştırmacılar tarafından yaygın olarak kullanılan sürekli karşılaştırmalı analiz yöntemi (Gravemeijer ve Cobb, 2006; Özdemir, 2016; Shattuck ve Anderson, 2013; Wang ve ark., 2014) kullanılmıştır. Bu yöntem araştırmacıların yeni ve önceden toplanan veriler arasında veya yeni ve mevcut kodlar arasında karşılaştırma yapmalarını sağlar (Shattuck ve Anderson, 2013). Bu çalışma için sürekli karşılaştırmalı analiz yönteminin seçilmesinin ana nedeni, mevcut tasarım tabanlı araştırmanın, uygulamanın öncesinde ve sonrasında olduğu gibi, çalışmanın farklı aşamalarında toplanan bir veri setini içermesiydi. Sürekli karşılaştırmalı yöntem, araştırmacının bu farklı veri setlerinden çıkan kodları ve kategorileri karşılaştırmasına ve yenilerini yaratmasını mümkün kılmıştır (Glaser ve Strauss, 2006). Benzer bir şekilde, araştırmacıların aralarındaki farklılıkları ve benzerlikleri ortaya koyarak farklı insanların aynı olayla ilgili deneyimlerini karşılaştırmasını sağlayan sürekli karşılaştırmalı yöntem (Mills, 2008), araştırmacının farklı katılımcıların aynı öğrenme sürecindeki deneyimlerini karşılaştırmasını sağlamıştır.

İlk olarak veri toplama araçlarından elde edilen tüm veriler yazılı hale getirilmiştir ve her bir veri kaynağı ve tüm çalışma hakkında bütüncül bir bakış açısı elde etmek için okunmuştur. Bu süreçte her bir veri kaynağında ortaya çıkan temel konular belirlenmiş ve bunlar hakkında notlar tutulmuştur (Bazeley, 2013). Bu adımı, ham verilerin göstergelere dönüştürülmesi izlemiştir. Bir katılımcının verilerinden elde edilen olaylar, kategoriler için temel oluşturmak amacıyla aynı veri setindeki diğer katılımcılardan elde edilen verilerle karşılaştırılmıştır (Charmaz, 2006). Bir sonraki adımda, göstergeler çeşitli kodlara ayrılmış ve sonra bu kodlar daha soyut kategorilere dönüştürülmüştür (Creswell, 2012). Kodlama tamamlandığında, kategorileri oluşturmak için benzer unsurlara sahip olan kodlar birleştirilmiştir (Strauss ve Corbin, 1990). Böylece, her gösterge, bu kategoride kodlanmış mevcut göstergelerle karşılaştırılarak birden fazla kategoriye kodlanabilmiştir. Bu kodlama süreci, mevcut kategorilere karşılık gelen yeni kategoriler ve göstergeler ortaya çıktıkça devam etmiştir (Glaser ve Strauss, 1965).

3. Bulgular ve Tartışma

Bu bölümde veri analizinden elde edilen bulgular sunulmuş ve ilgili alan yazın çerçevesinde tartışılmıştır. Bu bağlamda öncelikle, Okul Öncesi Eğitimde STEM Temelli Aile Katılımlı Mühendislik Tasarım Müfredatının (EDCPI) temel özellikleri ve okul öncesi çocuklara olası katkıları dört ana boyutta (bilgi, beceri, eğilim ve duygular) incelenmiştir. İkinci olarak ise, EDCPI’nın ebeveynlere ve okul öncesi öğretmenlerine olası katkılarına yönelik bulgular sunulmuş ve tartışılmıştır.

3.1 Okul Öncesi Eğitimde STEM Temelli Aile Katılımlı Mühendislik Tasarım Müfredatının Temel Özellikleri

Alan yazından hareketle belirlenen ve prototip aşaması boyunca geliştirilen tasarım ilkeleri, okul öncesi çocukların mühendislik ve STEM'deki öğrenmelerini aile katılımı aracılığıyla desteklemeyi hedefleyen bir müdahalenin tasarımı ve geliştirilmesine ilişkin yöntem ve içerik bilgisi sağlayarak gelecek araştırmalara rehberlik etmeyi amaçlamaktadır (Plomp, 2013). Bu temel özellikler prototip geliştirme aşamasından sonra son halini almış ve müfredatın tasarım ilkeleri olarak aşağıdaki alt başlıklarda açıklanmıştır.

3.1.1 Gelişimsel olarak uygundur

- *Öğrenme hedefleri açıkça tanımlanmış ve ifade edilmiştir*: Öğrenme hedefleri (kazanım ve göstergeler) ilgili alan yazın doğrultusunda belirlenmiş, açıkça tanımlanmıştır ve ilgili aktivite şablonunda öğretmenlere rehber olması açısından açıkça sunulmuştur.
- *Sınıf deneyimleri ve günlük yaşamla tutarlıdır*: Müfredat çocukların aşina olduğu ve hem okul yaşamlarıyla hem de okul dışındaki günlük yaşamlarıyla ilişkili öğrenme deneyimlerini içermektedir. Müfredat kapsamındaki etkinlikler, çocuklara mühendislik bilgisi ve görevlerinin nasıl ve nerede uygulanabileceğini gösteren gerçek yaşam durumlarıyla bağlantılı olarak düzenlenmiştir.
- *Gelişimsel ilgi, ihtiyaç ve özelliklere uygundur*: Müfredatta yer alan tüm faaliyetler ve ilgili öğrenme hedefleri, çalışılan yaş grubunun gelişimsel özellikleri ve ihtiyaçları ile kültürel ve aile bağlamları hakkında bilinenler ışığında belirlenmiştir. Bu noktada, müfredat kapsamındaki tüm müfredat materyalleri ve etkinlikleri, ilgili alan yazının rehberliğinde ve 60-72 aylık çocukların özelliklerini, ihtiyaçlarını, öğrenme yollarını ve aile ortamlarını bilen kaynaklardan biri olduğu için okul öncesi öğretmenleri ile iş birliği yapılarak hazırlanmıştır.
- *Mevcut erken çocukluk eğitimi (ECE) müfredatı ile bağlantılıdır:* Bu müfredat kapsamındaki öğrenme aktiviteleri mühendislik ve STEM ile ilgili öğrenme hedeflerine ek olarak, mevcut ECE müfredatında özellikle bilişsel, psikomotor ve sosyal-duygusal gelişim açısından hedeflenen bazı kazanım ve göstergelere de hitap edecek şekilde hazırlanmıştır. Müfredatı aynı zamanda mevcut ECE müfredatında yer alan pek çok kavram ile paralel şekilde hazırlanmıştır (e.g. uzun-kısa, ıslak-kuru, geniş-dar, büyük-küçük, önce-şimdi-sonra, kirli-temiz, ıslak-kuru, sert-yumuşak, içinde-dışında, yukarı-aşağı vb.) (Millî Eğitim Bakanlığı, 2013).

3.1.2 Öğrenme hedefleri dengeli şekilde dağılmıştır

Müfredatta yer alan öğrenme hedefleri, okul öncesi dönemde öğrenmenin dört temel boyutuna (bilgi, beceriler, eğilimler ve duygular) (Katz, 1999) ve çeşitli gelişim alanlarına (örneğin, sosyal, bilişsel, fiziksel) dengelenmiştir. Bu denge, bu müfredatta ele alınan beş farklı düşünce becerisi için de geçerlidir. Her ne kadar etkinliklerin çoğu, çocukları birden fazla düşünme biçiminde desteklemek için kullanılabilir olsa da müfredat, her biri bir düşünme becerisine odaklanan beş örnek etkinlik içermektedir.

3.1.3 Keşfederek öğrenme

Müfredat okul öncesi çocukları, öğrenme sürecine aktif şekilde katılmaya ve hem açık uçlu günlük materyallerle (ör. Lastik bant, plastik şişe, alüminyum folyo, kâğıt havlu, karton, kumaş, plastik kap, düğme, kasnak, mermer) hem de doğal materyallerle (örneğin yaprak, çam kozalağı, ağaç dalları, taşlar) keşfederek öğrenmeye teşvik etmektedir. Bu şekilde çocuklar, bu malzemelerin yüzey, boyut ve yapımlarında kullanılan malzemeler gibi farklı özelliklerini keşfetme fırsatını bulabilir. Ayrıca, müfredat çocukları soru sormaya ve mühendislik tasarım süreci yoluyla olası cevapları keşfetmeye teşvik ederek araştırma yoluyla öğrenmeyi desteklemektedir.

3.1.4 Tasarım yoluyla öğrenme

Bu müfredatta deneyimlenen mühendislik tasarım süreci, okul öncesi çocukların bir sorunu tanımalarını, olası çözümler hakkında düşünmelerini, çözümleri hakkında bir plan yapmalarını ve ebeveynlerinin rehberliğinde mühendislik tasarım sürecini deneyimleyerek çözümlerini test etmelerini ve geliştirmelerini sağlamaktadır. Bu bağlamda, her bir aktivitede çocuklara açık-uçlu (tek bir cevaptan ziyade pek çok çözüm ve cevaba izin veren) ve çocuğun yaratıcılığını güçlendiren tasarım problemleri sunulmaktadır.

3.1.5 Okul öncesi dönem çocuklarına STEM deneyimleri sağlar

STEM yaklaşımı üzerine temellendirilen bu müfredat çocuklara, STEM kavramları ile ilgili bilgi ve becerilerini mühendislik tasarım etkinlikleri aracılığıyla kullanma ve geliştirme fırsatını sağlamaktadır. Çocuklar müfredat içindeki mühendislik tasarım faaliyetlerinde yer alarak yalnızca mühendisliği değil aynı zamanda matematik ve fen bilimleri ilgili kavramları da deneyimlemektedir. Çeşitli tasarım problemlerine çözümler tasarlayan çocuklar aynı zamanda kendi teknolojilerini üretmektedirler.

3.1.6 Yaratıcılık ve günlük yaşam materyallerinin kullanımına dayalı deneyimlere önem verir

Müfredatta tüm öğrenme süreci çocukların yaratıcı potansiyelleri üzerine kurulmuştur. Müfredattaki tüm etkinlikler, çocukların kendilerini ve yaratıcılıklarını benzersiz bir şekilde ifade etmelerini sağlayacak şekilde tasarlanmıştır. Ayrıca, müfredatta yer alan tüm faaliyetler çocukların açık uçlu günlük yaşam materyallerini farklı şekillerde kullanmalarına izin veren faaliyetledir. Açık-uçlu materyaller tek başlarına ya da başka materyallerle kullanılabilen, taşınabilir, birleştirilebilir, yeniden tasarlanabilir, geri dönüştürülebilir, sıraya sokulabilir, parçalara ayrılabilir ve çeşitli şekillerde bir araya getirilebilir materyallerdir. Bu materyaller doğal (taşlar, ağaç dalları, kozalak, su, yapraklar, çakıl taşları, kum vb.), imal edilmiş (ahşap bloklar, karton, arındırılmış süt şişeleri, plastik kaplar, plastik borular, plastik ve tahta kaşıklar, kumaş, tuğla, vb.) ve/veya mevsime veya bulunulan bölgeye bağlı olarak temin edilebilecek materyaller (deniz kabukları, deniz yosunu, palmiye yaprakları vb.) olabilir (Neill, 2013).

3.1.7 Öğrenme süreci ebeveyn iskelesi ile desteklenmektedir

Müfredatın uygulanma süreci ebeveynlerin iskele yönteminde yer alan bazı stratejilerden yararlanmalıdır. Buna göre, ebeveynler çocukların problem çözme macerasına eşlik etmeli ve doğru cevapları vermek yerine çocukların doğru cevapları bulmalarına izin vermeli, başarının mutlaka bir ürün ortaya çıkarmak olmadığını hatırlamalı ve başarılı bir performansın nasıl görüneceği konusunda çocuklarıyla ortak bir anlayışa sahip olmalıdırlar. Ebeveyn çocuğun ne söylediğiyle ve ne yaptığıyla ilgilenmeli, çocuğun çalışmaları hakkında olumlu yorumlarda bulunmalı, ek destek için çocuğun ihtiyaçlarını yakından takip etmeli, çocukları ile duyarlı ve zevkli bir iş birliği kurmaya odaklanmalı, çocuğu başarılı olduğunda sözlü olarak övmeli, çocuğu başka bir çocukla veya çocuğun tasarımını başka bir çocuğun tasarımıyla karşılaştıramamalı, görevi çocuk tarafından başarılabilecek aşamalara bölerek ve çocuğun gerçekten yardıma ihtiyaç duyduğu durumlarda müdahale ederek sürece katkı sağlamalıdır.

3.1.8 Değerlendirme çok yönlüdür

Değerlendirmede hem öğrenme süreci hem de ortaya çıkarılan ürün önemlidir. Başarılı bir tasarımda, ürün çocuğun fikirlerini ve çabalarını yansıtmalıdır. Müfredatta ayrıca her çocuğun çok yönlü ve bireysel değerlendirmesine önem vermelidir. Bu değerlendirme, başlangıç noktası ile belirli bir zamanda ulaşılan nokta arasındaki farka bakılarak yapılmalıdır ve çocuğun öğrenme sürecini yansıtan portfolyolar ve müfredatta yer alan çocuk gözlem formları ile yapılmalıdır. Her bir ebeveyn-çocuk grubu için ayrı bir portfolyo dosyası oluşturulmalıdır.

3.2 Okul Öncesi Eğitimde STEM Temelli Aile Katılımlı Mühendislik Tasarım Müfredatının Okul Öncesi Çocuklara Katkıları

Çeşitli veri kaynakları aracılığıyla sağlanan ve sürecin farklı katılımcılarından elde edilen veriler dikkate alındığında, bulgular EDCPI'nin okul öncesi çocuklarına pek çok açıdan katkı sağladığını ortaya koymuştur. Bu katkılar müfredatın öğrenme hedefleri ve göstergeleri kapsamında ve dört ana boyutta tartışılmıştır.

3.2.1 Mühendisliğe İlişkin Bilgi

Sullivan ve Bers'in (2015) belirttiği gibi, çocukların yaşadıkları dünyayı anlamlandırmak için insan yapımı dünya hakkındaki bilgilerini ve mühendislik ve teknoloji anlayışlarını geliştirmelerini sağlamak önemlidir. Mevcut çalışmanın bulguları, müdahaleye katılmadan önce, okul öncesi çocukların mühendislikle ilgili sınırlı bir bilgiye sahip olduklarını ortaya koydu. Bulgular EDCPI'nın bilgi boyutundaki birçok öğrenme hedefine ulaşılmasını sağladığını ve böylece çocukların mühendislik ve teknoloji bilgisine birçok katkı sağladığını göstermiştir. Öyle ki, EDCPI çocukların mühendislik ve teknolojinin anlamı ve bu iki disiplinin dünyamız ve insanlık için önemi hakkında bir anlayış geliştirmelerini sağlamıştır. Ek olarak, EDCPI çocukların mühendisliğin insan yaşamının birçok alanında etkili olduğunu, cinsiyetten fark etmeksizin herkesin bir mühendis gibi düşünebileceğini ve mühendisliğin günlük hayatımızın bir parçası olduğunu düşünmesine katkıda bulunmuştur. Öyle ki, müdahalenin ardından çocukların çoğunun, mühendislerin hayatı kolaylaştırmak ve başkalarına yardım etmek için çalıştıklarının farkında oldukları ortaya çıkmış ve çocuklar günlük yaşamlarından mühendislik ürünlerine örnekler verebilmişlerdir. Bu bulgu, okul öncesi çağındaki çocukların gelişimsel olarak uygun bir mühendislik eğitimi yoluyla mühendislerin ve mühendisliğin nihai amacını anlayabildiklerini gösteren araştırmaları desteklemektedir (Bagiati ve Evangelou, 2018; Davis ve diğerleri, 2017; Raven ve diğerleri, 2018). Öte yandan, müfredatın iki farklı uygulaması, bir öğrenme hedefinin ve iki göstergenin bu yaş grubundaki çocuklar için uygun olmayabileceğini veya EDCPI yoluyla ulaşılamayabileceğini göstermiştir. Bunlar teknolojinin tanımını yapmak, mühendisliğin çeşitli alanlarını ve bu alanlarda çalışan mühendislerin ürettikleri teknolojilere dair örnekler sunmak ve mühendislik ile teknolojinin dünya üzerindeki etkilerini açıklamaktır. İlgili alan yazın doğrultusunda tasarlanan bu hedef ve göstergeler bu çalışmada gözlemlenmemiş ve bu nedenle, EDCPI'nın son prototipinden çıkarılmıştır.

3.2.2 Mühendisliğe İlişkin Beceriler

Bu çalışma okul öncesi çocukların doğal olarak bu mühendislik becerilerine sahip oldukları (Christenson ve James, 2015; Dorie ve diğerleri, 2014; English, 2018; Meeteren ve Zan, 2010; Tippett ve Milford, 2017) ve bu becerilerin ebeveyn katılımlı mühendislik eğitimi yoluyla desteklenebileceğini (Smetana ve ark., 2012) fikrine dayanmaktadır. Araştırma bulguları okul öncesi çocuklarının mühendislik tasarım sürecinin dört ana adımını başarılı bir şekilde deneyimleyebildiklerine işaret etmektedir. Öte yandan, mikro değerlendirme çalışmasından elde edilen bulgular, ebeveynlerin öğrenme sürecine aşırı müdahalesinin, çocukların mühendislik becerilerini gölgede bırakabileceğini ortaya koymuştur. Benzer bulgulara alan yazında da rastlamak mümkündür (e.g. Beal & Bers, 2006). Ancak, deneme çalışmasında ebeveynlerin bu aşırı müdahalesinin yerini ebeveyn iskelesine bırakması durumunda çocukların mühendislik becerilerini gösterip geliştirebildikleri gözlemlenmiştir. Bulgular ayrıca çocukların bu becerileri giderek ebeveynlerinden bağımsız olarak gösterdiklerine işaret etmiştir. Tüm bu bulgular okul öncesi çocuklarının mühendislik tasarım sürecini etkili bir şekilde deneyimleyebildikleri ve belirli sınırlılıklar çerçevesinde problemlere etkili çözümler üretebilecekleri yönündeki alan yazın bulguları ile paraleldir (Bagiati ve Evangelou, 2016; Davis ve diğ., 2017; Gold ve diğ., 2015; Malone ve diğ., 2018; Meeteren ve Zan, 2010; Torres-Crespo ve diğ., 2014).

3.2.3 Mühendisliğe İlişkin Eğilimler

Çalışmanın bulguları, her bir düşünme becerisi yalnızca bir etkinlik sırasında gözlemlenmiş olsa bile, çocukların beş düşünme becerisinin de hedeflerinin çoğunu gösterdiğini göstermiştir. Gözlemlenemeyen hedeflerin problem çözme sürecinde farklı kaynaklardan yararlanmak ve fikirleri gerekçelendirmeye yönelik olduğu bulunmuştur. Öte yandan, Bagiati'nin (2011) vurguladığı gibi, eğilimler uzun vadeli gözlem gerektirir, bu nedenle çocukların yalnızca bir etkinlik sırasında gözlemleyerek bu düşünme becerilerine sahip olup olmadıklarına dair yorum yapmak mümkün değildir. Benzer bir şekilde, bu düşünme becerilerine EDCPI yoluyla ulaşılıp ulaşılmadığını öngörmek de mümkün değildir. Bu nedenle, bu çalışmadan elde edilen bulgular, önerilen müfredatta yer alan öğrenme etkinlikleri sırasında, bu yaş grubundaki çocuklar tarafından hangi düşünme becerilerinin gösterilebileceğinin bir kanıtı olarak yorumlanmıştır.

3.2.4 Mühendisliğe İlişkin Duygular

EDCPI'nın son öğrenme boyutu duygulardır. Bulgular, müfredatın uygulanması boyunca çocuklar tarafından çoğunlukla olumlu duygular gösterildiğini ortaya koymuştur.

Çocukların, açık uçlu malzemelerle çeşitli mühendislik sorunlarına çözümler tasarlamaktan hoşnut olmaları ve ayrıca mühendislik faaliyetlerine katılmaya istekli olmalarının en sık gözlemlenen iki duygu olduğunu bulgusuna ulaşılmıştır. Benzer şekilde, çalışmasında, Bagiati (2011), mühendislik faaliyetlerine ilgi duymanın, mühendislik faaliyetlerine katılmaya istekli olmanın ve kaynaklardan memnun olmanın (örneğin materyaller) okul öncesi çocukların en sık gözlemlenen duyguları arasında olduğunu bulmuştur. Ayrıca Akgündüz ve Akpınar (2018) okul öncesi çocuklarının mühendislik temelli STEM faaliyetlerine karşı olumlu bir tutum ve yüksek motivasyona sahip olduklarını ortaya koymuştur. Aslında, gelişimsel olarak uygun bir mühendislik eğitiminde mühendislik, çocukların yaşadığımız dünyayı ve bu dünyanın nasıl çalıştığını öğrenmeleri için bir araç haline gelir (Van Meeteren, 2018) ve onlara anlamlı ve uygulamalı öğrenme deneyimleri sağlar (English, 2018). Bu özellikler, okul öncesi çocuklarının mühendislik faaliyetlerine katılma istekliliğinin ve memnuniyetinin kaynağı olabilir. Benzer şekilde, açık uçlu materyaller çocukların yaratıcılığını ve hayal gücünü serbest bırakır, yaratıcılıklarını geliştirir ve ilham verir (Neill, 2013). Bu nedenle, mühendislik faaliyetleri sırasında, yaratıcılıklarını ve hayal güçlerini ifade etmelerini sağlayan, aynı zamanda ucuz ve erişilebilir olan açık uçlu materyallerle çalışmak çocukları etkinlik sürecine motive etmiş olabileceği düşünülmektedir (Cunningham & Higgins, 2015).

3.3 Okul Öncesi Eğitimde STEM Temelli Aile Katılımlı Mühendislik Tasarım Müfredatının Ebeveynlere Katkıları

Bulgular, çalışma kapsamında önerilen müfredat ve verilen ebeveyn eğitiminin, ebeveynlerin mühendisliğe, erken çocukluk döneminde mühendisliğin rolü ve önemine, çocuklarının mühendislik eğitiminde kendilerine düşen rollere ve çocuklarının mühendislik ve STEM'deki öğrenmelerine rehberlik etme yollarına yönelik yönelik bilgi ve anlayışlarına katkı sağladığını göstermiştir. McClure ve diğ. (2017), ebeveynlerin çocuklarının mühendislik ve STEM konusundaki bilgi ve becerilerini nasıl güçlendirebilecekleri konusunda desteklendiğinde, gelişimsel olarak uygun bir iskele sağlayabildiklerini vurguladı. Mevcut araştırmadan elde edilen bulgular da EDCPI'nın, çocuklarının öğrenmelerini pekiştirmeleri için ebeveynleri desteklemenin etkili bir yolu olabileceğini göstermiştir.

Bulgulara göre, EDCPI'nın ebeveynlere başka bir katkısı da eğitimde aile katılımına yönelik anlayışları ile ilgilidir. Müdahaleden önce ebeveynler aile katılımını çocuklarla etkinlik yapmak, okul öğrenmelerini desteklemek ve okulda olup bitenden haberdar olmak olarak tanımlamışlardır. Bulgular, müdahalenin ardından, ebeveynlerin aile katılımına daha kapsamlı bir bakış açısıyla yaklaştığını ve aile katılımının çocuklarla eğlence veya eğitim amacıyla bazı faaliyetler yürütmek, çocuğu sorularla desteklemek ve çocukla iş birliği yapmak olarak tanımladığını ortaya koymuş ve müdahalenin çocuklarının mühendislik eğitiminde değerli olduklarını ve bu süreçte önemli rolleri olduğunu anlamalarına katkıda bulunduğunu göstermiştir.

3.4 Okul Öncesi Eğitimde STEM Temelli Aile Katılımlı Mühendislik Tasarım Müfredatının Okul Öncesi Öğretmenlerine Katkıları

Mevcut çalışmanın bulgularına göre, EDCPI okul öncesi öğretmenlerinin erken çocukluk döneminde mühendislik ve STEM bilgisine katkıda bulunmuştur. Aslında, müdahaleden önce, okul öncesi öğretmenleri, erken çocukluk döneminde mühendisliği yalnızca yapı-inşa ve takmalı-çıkarmalı eğitici oyuncaklar aracılığıyla gerçekleştirilen faaliyetler olarak görmekteydiler. Benzer şekilde, öğretmenlerin STEM hakkındaki bilgileri yalnızca internetteki örnek faaliyetlerle sınırlıydı. Mühendislik ve STEM erken çocukluk eğitimi alan yazınının yeni bir alanı olduğundan ve okul öncesi öğretmenlerinin çoğunluğu bu alanda herhangi bir eğitim veya deneyime sahip olmadığından bu bulgu pek de şaşırtıcı değildi. Öte yandan, Cunningham'ın (2009) vurguladığı gibi, çocukların anlayış ve becerilerini geliştirmelerine yardımcı olmak, öğretmenlerin konuyu kavramaları ve konuyu öğretme konusunda kendine güvenmelerini gerektirmektedir. Bulgular EDCPI'nın okul öncesi öğretmenlerine mühendislik ve STEM konusunda daha geniş bir perspektif kazanmalarını sağlayarak katkıda bulunduğunu göstermiştir. Müdahalenin ardından öğretmenler, çocuklara somut deneyimler yoluyla bazı bilimsel kavramları sunmaları gerektiğine, bu bilimsel kavramlarla ilgili çocukların farkındalığını artırarak gelecekteki öğrenmeleri için temel oluşturmaları gerektiğine ve çocukların öğrenmelerini gerçek hayatla ilişkilendirmeleri gerektiğine inandıklarını ifade etmişlerdir. Bulgular aynı zamanda, müfredatın mühendislik ve STEM'i sınıflarına entegre etme konusunda öğretmenlerin motivasyonunu artırdığını ortaya çıkarmıştır. Bu bulgu, STEM'in ve erken çocukluk eğitimine entegrasyonunun önemini ve uygunluğunu savunan çalışmalarla paraleldir (Ata-Aktürk ve diğ., 2017; Davis ve diğ., 2017; Moomaw ve Davis, 2010; Park, Dimitrov, Patterson, & Park, 2017).

4. Öneriler

Araştırmanın bulguları EDCPI'nın okul öncesi çocukların mühendislik ve STEM'deki öğrenmelerini desteklemek ve ebeveynlere çocuklarının mühendislik eğitimini desteklemenin yollarına yönelik bilgi sağlamak için kullanışlı ve etkili bir müfredat olduğunu ortaya koymuştur. EDCPI ayrıca çocukların okulda, ev ortamında ve günlük yaşamda mühendislik örneklerini fark etmelerini sağlama ve okul öncesi çocukları ve ebeveynlerini çeşitli bağlamlarda mühendislik tasarım sürecine dahil etme noktasında okul öncesi öğretmenleri için etkili bir kaynak teşkil etmektedir (Smetana ve diğ., 2012). Mevcut çalışmanın bulguları, böyle bir müfredatla okul öncesi çocukların mühendislik konusundaki bilgi ve becerilerini geliştirmek, bazı matematik ve fen bilgisi ile ilgili kavramlar hakkındaki bilgilerini ve anlayışlarını geliştirmek ve çocukları ev ortamında da mühendislik yapmaya motive etmenin mümkün olduğunu göstermiştir. Benzer şekilde, bulgular, böyle bir müfredatın, ebeveynlerin mühendislik anlayışını ve mühendislik ve teknolojinin yaşamımızdaki önemini anlamalarını teşvik edebileceğini göstermiştir. EDCPI ayrıca ebeveynlere okul öncesi dönemde mühendislik eğitimi bilgisi ve bunu nasıl destekleyebilecekleri konusunda bilgi sağlayabilir. Tüm bu bulgular ışığında, EDCPI'nın okul öncesi sınıflarında, okul öncesi öğrencilerin mühendislik ve STEM'in diğer alanlarındaki öğrenmelerini teşvik etmek için ve aile katılımının etkili ve alternatif bir yolu olarak kullanılabileceği sonucuna varılabilir. EDCPI, STEM'i sınıflarına dahil etmek isteyen okul öncesi öğretmenlerine ihtiyaç duydukları rehberliği ve süreçte ebeveynlerin desteğini almalarını sağlayabilir.

Tasarlanan ve geliştirilen müfredatın kullanımıyla ilgili önemli bir sonuç, esnekliği ve uyarlanabilirliğidir. Tasarım ilkelerinde belirtildiği gibi, bulgular, EDCPI'nin okul öncesi öğretmenlerinin, müfredat içeriğini sınıflarındaki çocukların ve ebeveynlerin ihtiyaçlarına ve özelliklerine uyarlamasına olanak tanıyan bir müfredat olduğunu ortaya koymuştur. Aslında, EDCPI okul öncesi öğretmenlerine sınıf uygulamaları ve biçimlendirici değerlendirme yoluyla gerçek sınıf ortamında test edilmiş ve revize edilmiş örnek mühendislik etkinlikleri sunmaktadır. Bu nedenle, öğretmenler EDCPI etkinliklerini sınıflarına adapte ederek uygulayabilir veya EDCPI etkinlik şablonlarından faydalanarak kendi sınıfları için ebeveynleri de içeren benzer mühendislik etkinlikleri tasarlayabilirler. Kapsamlı bir literatür taraması ile belirlenen ve sınıf uygulamaları ile doğrulanan kazanım ve göstergeler, okul öncesi öğretmenlerine erken çocukluk dönemi mühendislik eğitimi için bir çerçeve sağlayabilir ve böylece uygulamalarına ışık tutabilir. Bu şekilde, okul öncesi öğretmenleri bu öğrenme hedeflerine ve göstergelerine başvurarak sınıfları için benzer aile katılımlı mühendislik etkinlikleri tasarlayabilir.

Daha önce de belirtildiği gibi, EDCPI okul öncesi çocukların hafta içerisinde gerçekleşen öğrenmelerini desteklemek ve yeni öğrenme deneyimleri sağlamak için okul müfredatının dışında uygulanacak şekilde tasarlanmış ve geliştirilmiştir. Bununla birlikte, izlenen tasarım süreci, tasarım problemlerinin çocuklara gelişimsel olarak uygun bir şekilde sunulması ve bazı bilimsel kavramları öğretimindeki uygulamalı deneyimler, okul öncesi öğretmenlerinin sadece çocuklarla ve okul müfredatına entegre ederek uygulayabileceği mühendislik etkinlikleri tasarlaması için yararlı bir kaynak olabilir. Bu nedenle, okul öncesi çocukları mühendislik tasarım sürecini öğretmenleri tarafından müfredata entegre edilmiş bir şekilde tasarlanan mühendislik etkinlikleri aracılığıyla akranlarıyla deneyimleyebilir ve daha sonra da EDCPI aracılığıyla hafta sonlarında öğrenimlerini güçlendirme ve ebeveynleriyle iş birliği yapma fırsatı bulabilirler.

Çalışmanın bir diğer çıkarımı ECE müfredat geliştiricileriyle ilgilidir. Mevcut ECE müfredatı STEM entegrasyonu için uygundur ancak mühendislik ve teknoloji müfredat içeriğinde çok sınırlı bir yere sahiptir (Ata-Aktürk ve diğ., 2017). Bu araştırmadan elde edilen bulgulara göre, mühendislik eğitimi gelişimsel olarak uygun bir şekilde uygulandığında okul öncesi çocuklar sadece mühendislikle ilgili değil, aynı zamanda fen ve matematikle ilgili kavramlar hakkında da bilgi edinebilir ve bu alanlarda beceri kazanabilirler. Bu kavram ve becerilerin çoğu, mevcut ECE müfredatında ulaşılması gereken hedeflerle paralellik göstermektedir. Ayrıca, bulgularla da desteklendiği gibi, mühendislik eğitimi, çocuklara mühendislik ve diğer STEM disiplinlerinde de bilgi ve beceri sağlamaktadır. Ek olarak, mühendislik eğitiminde deneyimlenen mühendislik tasarım süreci, çocukların işbirlikçi, esnek, kalıcı, meraklı ve yansıtıcı düşünme becerilerini sergiledikleri bir süreçtir. Tüm bu beceriler, alan yazında 21. yüzyıl becerileri arasında sayılmaktadır (P21, 2016). Bu çalışmanın bulguları, çocukların mühendislik tasarım sürecinde yaratıcılıklarını gösterebildiklerini ve kendilerini ifade edebildiklerini, başarısızlık karşısında olumsuz duygularla başa çıkabildiklerini ve başarısız girişimleri öğrenme fırsatlarına çevirebildiklerini göstermiştir. Başka bir deyişle, bulgular mühendislik eğitiminin okul öncesi çocukları bilişsel, duygusal, sosyal ve motor gelişimini, hayal gücü ve yaratıcılıklarını desteklediğini ortaya koymuştur. Tüm bu açılardan, bu çalışma okul öncesi dönemde mühendislik eğitiminin mevcut müfredata paralel olduğunu ve mevcut müfredatın mühendislikle ilgili öğrenme amaçları ve göstergeleri ve örnek faaliyetler açısından geliştirilebileceğine işaret etmektedir.

Appendix Y: Thesis Permission Form / Tez İzin Formu

TEZ İZİN FORMU / THESIS PERMISSION FORM

ENSTİTÜ / INSTITUTE

Fen Bilimleri Enstitüsü / Graduate School of Natural and Applied Sciences ☐

Sosyal Bilimler Enstitüsü / Graduate School of Social Sciences ■

Uygulamalı Matematik Enstitüsü / Graduate School of Applied Mathematics ☐

Enformatik Enstitüsü / Graduate School of Informatics ☐

Deniz Bilimleri Enstitüsü / Graduate School of Marine Sciences ☐

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TEZİN ADI / TITLE OF THE THESIS (**İngilizce** / English) : DEVELOPMENT OF A STEM BASED ENGINEERING DESIGN CURRICULUM FOR PARENTAL INVOLVEMENT IN EARLY CHILDHOOD EDUCATION

TEZİN TÜRÜ / DEGREE**:** **Yüksek Lisans** / Master ☐ **Doktora** / PhD ■

1. **Tezin tamamı dünya çapında erişime açılacaktır. /** Release the entire work immediately for access worldwide. ■
2. **Tez iki yıl süreyle erişime kapalı olacaktır.** / Secure the entire work for patent and/or proprietary purposes for a period of **two years. *** ☐
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A copy of the decision of the Institute Administrative Committee will be delivered to the library together with the printed thesis.

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