DEVELOPING EFFECTIVE SOCIOSCIENTIFIC ISSUES TEACHING PRACTICES THROUGH EDUCATIONAL DESIGN RESEARCH

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Prof. Dr. Tülin GENÇÖZ
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy.

Assoc. Dr. Elvan ŞAHİN
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy.

Assoc. Prof. Dr. Nejla YÜRÜK
Co-Supervisor

Prof. Dr. Özgül YILMAZ TÜZÜN
Supervisor

Examining Committee Members

Prof. Dr. Mehmet Fatih TAŞAR (Gazi Uni, MSE) ______________________

Prof. Dr. Özgül YILMAZ-TÜZÜN (METU, MSE) ______________________

Prof. Dr. Semra SUNGUR (METU, MSE) ______________________

Prof. Dr. Ceren ÖZTEKİN (METU, MSE) ______________________

Assist. Prof. Dr. Ümit DEMİRAL (Ahi Evran Uni, BE) ______________________

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name : Meltem IRMAK

Signature :

ABSTRACT

DEVELOPING EFFECTIVE SOCIOSCIENTIFIC ISSUES TEACHING PRACTICES THROUGH EDUCATIONAL DESIGN RESEARCH

Irmak, Meltem
Ph.D., Department of Elementary Education
Supervisor: Prof. Dr. Özgül YılmazTüzün
Co-Supervisor: Assoc. Prof. Dr. Nejla Yürük

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The main purpose of this study was to develop pre-service science teachers' (PSTs) effective socioscientific issues (SSI) teaching practices with technology by activating their metacognition. For this purpose, educational design research was utilized to re-design an undergraduate course. Re-designed course was implemented in the fall semester of 2014-2015 with 36 participants. In light of the results of the data obtained in the first implementation, expert reviews and the related literature, the design of the course was revised and the course was implemented in the fall semester of 2015-2016 with 44 participants. In order to collect data, lesson plans, video-recording of teachings, video-stimulated recall interviews, reflection papers and post-teaching structured interviews were utilized. The analysis of the data provided information about the nature of PSTs' SSI teaching practices with technology and the nature of their metacognition as well as the effectiveness of the course. The results indicated an increase in the awareness of PSTs' about four areas of pedagogical importance central to the teaching of SSI: (1) nature of science issues, (2) classroom discourse issues, (3) cultural issues, and (4) case-based issues. The results also showed that PSTs who were engaged in productive metacognitive thoughts prepared better lesson plans in their individual lesson plans. Moreover, the groups, whose members' monitoring and regulation skills were good, enacted their lesson plans effectively. Moreover, the evolution of design principles throughout the study was also explained. At the end of the study, fourteen final design principles were explicated and their effectiveness was discussed to guide further design attempts.

Keywords: Socioscientific Issues Teaching, Technological Pedagogical Content Knowledge, Teacher Metacognition, Educational Design Research

ÖZ

ETKİLİ SOSYOBİLİMSEL KONULAR ÖĞRETİMİ PRATİKLERİNİN EĞİTİM TASARIM ARAŞTIRMASI İLE GELİŞTİRİLMESİ

Irmak, Meltem
Doktora, İlköğretim Bölümü
Tez Yöneticisi: Prof. Dr. Özgül Yılmaz-Tüzün
Ortak Tez Yöneticisi: Doç. Dr. Nejla Yürük

Ocak 2018, 487 sayfa

Bu çalışmanın temel amacı, fen bilgisi öğretmen adayların (FBÖA) sosyobilimsel konuları (SBK) teknoloji ile etkili öğretme deneyimlerini üstbilişlerini aktive ederek geliştirmektir. Bu amaçla bir lisans dersi eğitim tasarımı araştırması yoluyla yeniden tasarlanmıştır. Yeniden tasarlanan ders, 2014-2015 sonbahar döneminde 36 katılımcı ile uygulanmıştır. İlk uygulama, uzman incelemeleri ve ilgili literatürden elde edilen verilerin ışığında dersin tasarımı revize edilmiş ve ders, 44 katılımcıyla 2015-2016 sonbahar döneminde tekrar uygulanmıştır. Veri toplamak için ders planları, öğretimin video kayıtları, videoyla uyarılmış geri çağırma görüşmeleri, yansıtıcı değerlendirme kağıtları ve öğretim sonrası yapılandırılmış görüşmeler kullanılmıştır. Verilerin analizi, FBÖA'nın teknoloji ile SBK öğretim uygulamalarının doğası ve üst bilişlerinin yapısı ve dersin etkinliği hakkında bilgi sağlamıştır. Sonuçlar, FBÖA'nın SBK öğretiminde önemli olan dört pedagojik alan hakkındaki farkındalıklarında bir artışa işaret etmiştir: (1) fen konularının doğası, (2) sınıf söylemi konuları, (3) kültürel konular ve (4) durum-tabanlı konular. Sonuçlar, aynı zamanda, etkili üstbilişsel düşünceye sahip olan FBÖA'nın bireysel ders planlarında daha iyi ders planları hazırladığını da göstermiştir. Ayrıca, üyelerinin izleme ve düzenleme becerileri iyi olan gruplar, ders planlarını etkili bir şekilde uygulayabilmişlerdir. Son olarak, çalışma boyunca tasarım prensiplerinin değişimi de açıklanmıştır. İleride yapılacak çalışmalara rehber olması için çalışma sonunda ortaya çıkan ondört nihai tasarım prensibi açıklanmış ve etkililiği tartışılmıştır.

Anahtar kelimeler: Sosyobilimsel Konuların Öğretimi, Teknolojik Pedagojik Alan Bilgisi, Öğretmen Üstbilişi, Eğitim Tasarım Araştırması

To my beloveds

Zeynep and Hasan Irmak

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DP	:	Design Principle
EDR	:	Educational Design Research
FI	:	First Implementation
GLP	:	Group Lesson Plans
ILP	:	Individual Lesson Plans
PCK	:	Pedagogical Content Knowledge
PST	:	Preservice Science Teachers
PTSI	:	Post-Teaching Structured Interviews
RP_1	:	Reflection Paper 1
RP_2	:	Reflection Paper 2
RP_3	:	Reflection Paper 3
SI	:	Second Implementation
SSI	:	Socio-Scientific Issue
TMF	:	Teacher Metacognitive Framework
TPACK	:	Technological Pedagogical Content Knowledge
VSRI	:	Video-Stimulated Recall Interviews
LPER-TIST	:	Lesson Plan Evaluation Rubric for Technology Integration into SSI Teaching
TPER-TIST	:	Teaching Performance Evaluation Rubric for Technology Integration into SSI Teaching

CHAPTER 1

INTRODUCTION TO THE STUDY

Many researchers outlined the need for the inclusion of the science, technology, and society (STS) approach in science education because science is only meaningful when it is taught by considering its effect on technology and, in turn, effect on society (Zeidler et al., 2005). STS approach has more than 30 years of history (Aikenhead, 1980; Solomon & Aikenhead, 1994; Yager, 1996). The major aim to include STS in science education was defined by Pedretti (1997) as follows:

> to develop an effort to interpret science and technology as complex socially embedded enterprises, and to promote the development of critical, scientifically and technologically literate, citizenry capable of understanding STS issues, empowered to make informed and responsible decision, and able to act upon those decisions (p.1211).

During the decades that followed the first definition of STS approach, many countries around the world had attempted to make reform initiatives in the light of STS approach (Yager, Lim, & Yager, 2006). Today, STS approach is still implemented in the national science curriculum of Turkey (MoNE, 2013).

The vision of National Science Education Program was defined as "to raise scientifically literate individuals" (MoNE, 2013). In this education program, scientifically literate individuals' characteristics were also clarified so that scientifically literate individuals are inquirers, effective decision maker, problem solver, self-confident, open to collaboration, effective communicator, aware of the sustainable development and life-long learning; and these individuals have knowledge, skill, positive attitude, value and perception about science; understanding and psychomotor skills about the relationship of science with technology, society and environment. To reach these aims, science curriculum has four learning areas, which are knowledge, skill, affect and science-technology-society-environment. Socio-scientific issues (SSI) are one of the sub-domains of STSE learning area along with nature of science, science and technology relationship, societal contribution of science, awareness of sustainable development and awareness of science and career. SSI sub-dimension was defined in the curriculum as the scientific and moral reasoning regarding the socio-scientific problems related to science and technology (MoNE, 2013).

Zeidler et al. (2005) made clear the need for the movement beyond STS to SSI for a more comprehensive framework. Although both approach similarly aim to teach science in a social context, the difference between the labels gain importance beyond individual classrooms, when the terms represent a theoretical framework (Sadler, 2009). STS approach has also been very important contribution to science teaching in terms of connecting science with societal issues; however, it has become very wide collection of activities that cannot be unified under a single theoretical approach (Sadler, 2009). Therefore, SSI offers more comprehensive framework to researcher by adding students' moral and ethical developments as an important component to STS(E) approach (Zeidler et al., 2005). SSI is a more comprehensive framework that besides all of the dimensions that STS offers, it consists of the ethical dimensions of science, the moral reasoning and the emotional development of the student (Zeidler, Walker, Ackett, & Simmons, 2002). The SSI framework emphasizes four areas of pedagogical importance central to the teaching of SSI: (1) nature of science issues, (2) classroom discourse issues, (3) cultural issues, and (4) case-based issues (Zeidler et al., 2005). These issues aims to promote students' intellectual development and, in turn, their scientific literacy.

In this study, the main purpose was to develop an educational design to help pre-service science teachers (PSTs) teach SSI effectively, so that they can raise scientifically literate citizens as it was stated in the curricular goals. The aim of this study was to re-design an undergraduate course to develop PSTs' practices related to effective SSI teaching with technology. In the following sections, I clarified the problem statement based on the related literature, the overview of the research design of the study. Then I explained the research questions of the study congruent with the nature of EDR. The chapter continued with the significance of the study. Then, I explained the theoretical perspective, which is social constructivism, guiding the study. At the end of the chapter, I clarified the definitions of some basic concepts and then explained the organization of the chapters.

1.1. Problem Statement

The ultimate goal of science education is raising scientifically literate citizens. In recent years, the role of teaching via socio-scientific issues (SSI) in contributing to the students' scientific literacy has been recognized by international science education community as well as national educational policy makers (MoNE, 2013; Zeidler & Keefer, 2003; Zeidler & Nichols, 2009; Zeidler, Sadler, Simmons, & Howes, 2005). Recent studies emphasized the importance of using SSI as a context in science education for its potential to develop students' subject matter knowledge, informal reasoning, evidence-based decision-making, reflective judgment, argumentation, and moral reasoning (Klosterman & Sadler, 2010; Zeidler, Sadler, Applebaum, & Callahan, 2009). Moreover, teaching science in SSI context requires the consideration of ethical issues and moral judgments about the scientific issues through social and scientific inquiry (Zeidler & Keefer, 2003). Therefore, SSI teaching fosters the development of social and moral reasoning and character in students through the classroom discourse that students are expected to engage in (Zeidler et al., 2005; Zeidler & Nichols, 2009). While learning science in SSI context, students can be engaged in both personal and social knowledge construction.

In addition to multifaceted outcomes of SSI teaching, it has some challenges compared to teaching a certain scientific principle. Although teachers have knowledge and ability to implement standardized curriculum, teaching with SSI-based curriculum including the pedagogical practices necessary for the delivery of SSI approach is relatively new for teachers (Zeidler et al., 2009). Teaching SSI necessitates a shift in teachers' approach from traditional content-based and value-free science teaching approach to sociocultural approach viewing science as a community of practice and students as the active participants in decision-making (Tal & Kedmi, 2006). This requires developing students' argumentation skills, ability to comprehend the complexity of issues, and awareness concerning the reliability of data

(Zeidler & Nichols, 2009). Teachers who teach science in SSI context with social constructivist approach should allow individuals and groups to communicate and collaborate for knowledge construction (Tal & Kedmi, 2006). Therefore, SSI teaching brings some challenges to teachers. However, integrating technology into SSI teaching has potential to lighten teachers' burden on these relatively new and challenging tasks.

Research showed that integrating technology into SSI teaching increased motivation, engagement, and learning of students thanks to different affordances of the utilized technology (Belland, Gu, Armbrust, & Cook, 2015; Chang, Wu, & Hsu, 2013; Klosterman & Sadler, 2008). Chang et al. (2013) suggested that using a mobile augmented reality activity promoted students' understanding of SSI content; enhanced situatedness and a sense of closeness to SSI. Moreover, Belland et al. (2015) investigated the influence of different scaffoldings on students' abilities to create and evaluate arguments and found that computer-based scaffolds increased the ability of low-achieving students to evaluate the arguments in SSI.

Web-based SSI teaching contexts were argued as invaluable resources in terms of informing students about diverse perspectives and claims about an SSI (Zeidler & Nichols, 2009). Similarly, Klosterman and Sadler (2008) discussed the affordances of WebQuest in increasing students' interest level and encouraging them to make decisions regarding complex SSI. According to Walker and Zeidler (2003), developing effective internet-based learning environments are effective for helping students not only to learn about the science content knowledge inherent in SSI but also to experience the way scientists solve or research the issue. Therefore, creating social constructivist learning environments with the help of technology was assumed to be helpful in increasing the effectiveness of SSI teaching.

Although using technology has affordances in SSI teaching, it brings along some challenges for teachers to be concerned. For example, using web-based SSI teaching contexts requires teachers to spend more time to find reliable sources of scientific data and perspective, because teachers are responsible to teach students deal with mixed evidences and assess the validity of varied claims and data (Zeidler & Nichols, 2009). Moreover, as Furberg and Ludvigsen (2008) pointed out, web-based ICT resources offer open-ended environments to work on socio-scientific issues and students need certain abilities to make meaning of scientific concepts found in these environments. At this point, teacher should also have some responsibilities. Teacher should be able to both facilitate students' working process on ICT and intervene in students' meaning making of SSI in ICT-mediated settings (Furberg & Ludvigsen, 2008). The teacher should have the ability to track students' talk and activity in these settings. Moreover, as Ratcliffe and Grace (2003) foreseen, since today's students have increased access to variety of information sources, teachers should be able to deal with incomplete and possibly biased media information that can be reached through Internet searching, and email communication with people who have a wide variety of expertise and viewpoints for effective SSI teaching.

It can be said that teachers should know the affordances and constraints of technologies that can be used in SSI teaching to be able to select proper technologies, implement effective technology integrated SSI teaching lessons and evaluate the effectiveness of them on students' learning. Teachers should be aware of the capabilities of multimedia in creating learning environments that provide opportunity to reach information on current SSI and highly engaging meaningful learning experiences (Walker & Zeidler, 2003). Therefore, teachers should have a deep understanding of SSI topics, the pedagogy of SSI teaching as well as technology integration knowledge to be able to facilitate their SSI teaching. Therefore, in this study, in order to increase PSTs effectiveness in SSI teaching, their technology integration knowledge was decided to be developed.

In the last decade, researchers conducted systematic research studies to develop a theoretical perspective on technology integration knowledge, because only if teacher knowledge is defined clearly, effective teacher education programs can be designed and implemented properly (Hsu, 2015). Researchers tried to define the knowledge required for effective technology integration under different labels like integration literacy (Gunter & Baumbach, 2004); information and communication (ICT)-related pedagogical content knowledge (PCK) (Angeli & Valanides, 2005); or pedagogical technology knowledge (Guerrero, 2005). Although they used different labeling, the similarity between these studies was the emphasis on the importance of technology, pedagogy, and content knowledge. The researchers argued that these three knowledge bases (technology, pedagogy and content) and the interaction among them constitute the hearth of the technological pedagogical content knowledge (TPACK) (Koehler & Mishra, 2005a, 2005b; Koehler, Mishra, Hershey, & Peruski, 2004; McCrory, 2004; Mishra & Koehler, 2006; Niess, 2005).

Koehler and Mishra (2008) argued that TPACK is more than what all three knowledge individually is and defined it comprehensively as follows:

> TPCK is the basis of effective teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies to strengthen old ones. (pp. 17-18)

TPACK framework was based on Shulman's Pedagogical Content Knowledge (PCK) framework (Shulman, 1987). Shulman (1987) emphasized the importance of both pedagogical knowledge and content knowledge in teacher education programs rather than having a perspective of content knowledge versus pedagogical knowledge. Shulman's (1986, 1987) PCK notion emphasized transformation of content knowledge into pedagogically sound forms by considering the classroom context and teaching experiences. However, the potential of technology in transforming content and pedagogy for learners was not explicitly defined in PCK notion (Angeli et al., 2016). PCK was expanded to TPACK with the contribution of different researchers by adding another body of knowledge, namely technology knowledge (TK). The resulting framework provided valuable information for researchers to study teachers' cognition about technology integration to increase the effectiveness of their content teaching. Therefore, in order to examine PSTs' effective SSI teaching with technology, TPACK framework was utilized.

Activating metacognition was found to be effective for TPACK development in pre-service and in-service teacher education (Doering, Veletsianos, Scharber, & Miller, 2009; Kramarski & Michalsky, 2010). In Doering et al.'s (2009) study, making teachers think about TPACK explicitly encouraged them to be metacognitive about teacher knowledge strengths and areas of growth. Moreover, Kramarski and

Michalsky (2010) confirmed that preservice teachers must be explicitly taught about the interactions among technology, content, and pedagogy for TPACK development.

Moreover, the importance of metacognition in problem solving has been argued in the literature (Kapa, 2007; Kramarski & Mevarech, 2003; Kramarski, Mevarech, Arami, 2002; Mayer, 1992; Mevarech & Fridkin, 2006; Mevarech & Kramarski, 2003; Swanson, 1990). Swanson (1990) revealed the positive effect of children's declarative knowledge of cognition on the regulation of problem solving process. Similarly, Kapa (2007) investigated the effect of metacognitive training in different phases of problem solving and showed the significant effect of metacognitive training in interactive and postactive problem solving process on the performance of solving structured and open-ended problems. Mevarech and her colleagues investigated the effect of a metacognitive instructional method, IMPROVE (Introducing new concepts, Metacognitive questioning, Practicing, Reviewing and reducing difficulties, Obtaining mastery, Verification, and Enrichment), on problem solving skills. Through different experimental studies, the researchers showed that students who were exposed to IMPROVE training outperformed the control groups in solving authentic and everyday life mathematical tasks and performed improved mathematical knowledge and mathematical reasoning (Kramarski et al., 2002; Mevarech & Fridkin, 2006; Mevarech & Kramarski, 2003).

Research on problem-solving and metacognition mainly attempted to investigate the improvement in metacognitive skills through interventions in the scope of mathematical problem solving and the sample of the studies mostly constituted the schoolchildren and undergraduate students (Metallidou, 2009). However, the role of metacognition in real problem-solving situations, which are ill-defined, open-ended questions without algorithms in their solutions were also investigated (Mayer, 1992; Berg, Strough, Calderon, Sansone, & Weir, 1998; Patrick & Strough, 2004). For example, Artzt and Armour-Thomas (1998) investigated the role of metacognition in a real problem-solving situation, which is teaching mathematics.

Artzt and Armour-Thomas (1998) conceptualized mathematics teaching as problem-solving process. Using "teaching as problem-solving" perspective, the researchers defined the components of metacognition underlying the instructional practice of seven experienced and seven beginning secondary school mathematics teachers and developed the Teacher Metacognitive Framework (TMF) to examine the thoughts of teachers. In this model, the researchers differentiated the teaching processes as preactive, interactive and postactive stages to investigate teacher thoughts before, during and after instructional practice. The researcher defined the actual enactment of the lesson in the classroom as cognitive component of problem-solving endeavor while conceptualizing metacognitive components of problem-solving as teachers' commentaries about their goals, beliefs, knowledge, planning, monitoring, regulating, assessing and revising.

In TPACK literature, researchers characterized technology integration as "wicked problem" which is unique, and ill-structured problem (Koehler & Mishra, 2008; Mishra & Koehler, 2006; Niess, 2012, 2015). Therefore, any attempt to integrate technology into instructional practice can be regarded as solving this wicked problem. Integrating technology into science education in the context of SSI even makes the task more challenging for teachers. The nature of SSI makes its teaching difficult for teachers because SSI topics have a complex nature as compared to other science concepts (Ratcliffe & Grace, 2003).

Therefore, teaching SSI requires developing students' reasoning skills in many respects as well as understanding in scientific concepts. To do so, teachers need to engage students in decision making in small group or large group discussions and manage these processes effectively. Integrating technology into these processes requires teachers' thoughtful decisions about the nature of SSI, related pedagogy and technology to teach SSI effectively. Therefore, teachers should systematically think about the way of integrating technology into SSI teaching, before, during and after the teaching process to increase the effectiveness of their SSI teaching. Therefore, from "teaching as problem solving" perspective, in the current study, the problem to be solved by the pre-service teachers is increasing the effectiveness of their SSI teaching through technology integration.

The metaphors of problem solver (Artz and Armour-Thomas, 1998) or learner (Marchant, 2001) for teachers laid emphasis on the importance of teachers' thinking processes in teaching. Teachers should think about their own thinking regarding their teaching (Hartman, 2001; Marchant, 2001; Schon, 1987). Hsu (2015) stated that "teaching is a part of a complex decision-making process in which factors involved in the process of teaching and learning need to be considered carefully before, during and after the actual event" (p.5). Teachers need to teach metacognitively to promote the effect of their teaching before, during, and after the teaching process (Ya-Hui, 2012). Therefore, metacognition plays a crucial role in the development of pre-service and in-service teachers' TPACK development for effective SSI teaching. Therefore, while developing PSTs effective SSI teaching practices with technology, their metacognition about their practices were decided to be activated.

The main purpose of this study was to develop PSTs' effective SSI teaching practices with technology by activating their metacognition about their SSI teaching. That is, a theoretical understanding about the nature of PSTs' SSI teaching knowledge with technology was aimed to be produced as an output of the study. This aim was tried to be achieved by re-designing a course, offered in science education undergraduate department of a public university. Therefore, the other goal of this study was to re-design an effective undergraduate course to develop pre-service science teachers' effective SSI teaching practices with technology by activating their metacognition. By this way, a practical contribution was tried to be made to the field with the intervention developed to solve a real problem, which is developing PSTs' effective SSI teaching practices with technology. Thus, the aim of this study was two-fold:

1. To develop pre-service science teachers' effective SSI teaching practices with technology by activating metacognition in an SSI teaching undergraduate course
2. To identify design principles and characteristics of an SSI teaching undergraduate course for the purpose of developing pre-service science teachers' SSI teaching practices with technology by activating metacognition

To reach these two overarching purposes of the dissertation, Educational Design Research (EDR) was decided as the most appropriate methodological approach. In the next section, a brief overview of the research design of this study was given.

1.2. Research Design Overview

EDR studies are iterative, flexible and use-inspired in nature (McKenney & Reeves, 2012) (see 3.3 Educational design research (EDR) for detailed information about the characteristics of EDR); however, systematic and purposeful implementation of research methods is needed (Wang & Hannafin, 2005). There are different models and frameworks defining the process followed in conducting EDR. Ejersbo et al. (2008) developed the "osmotic model" to represent the balance between artifact and theory development in EDR. Bannan-Ritland and Baek (2008) defined the design research as a complex, practical, and "wicked" journey and outlined the research questions and methods through the phases of the Integrative Learning Design Framework (ILDF). Moreover, different researchers explained the design research processes from a learning design perspective (Gravemeijer & Cobb, 2006), technology perspective (Reeves, 2006) and curriculum perspective (McKenney, Nieveen, & van den Akker, 2006).

The common characteristic of different models of EDR is the emphasis on iterative and flexible nature of EDR studies; although, they may vary in detail. Mostly, the whole design research process consists of three main phases, a preparation phase for design experiment, a development, prototyping or enactment phase, and an evaluation or retrospective analysis phase. Although some researchers further divided these phases into more detailed phases, all of the researchers agreed with the need for systematic implementation of research methods before, during and after the design experiments.

McKenney and Reeves (2012) produced a generic model for educational design research by considering the compatibility with EDR studies from different fields, at various scales, scopes and settings (Figure 1). Similar to the other models cited in the literature, this generic model includes three main phases explaining flexible and iterative processes. Although other models gave attention to the role of theory to some extent (Gravemeijer & Cobb, 2006), McKenney and Reeves (2012) emphasized the dual focus on theory and practice in all phases of the model. Moreover, this model reflects the use-inspired nature of EDR. This generic model was considered in framing this dissertation. Therefore, there were three main phases of this study, which were briefly explained below.

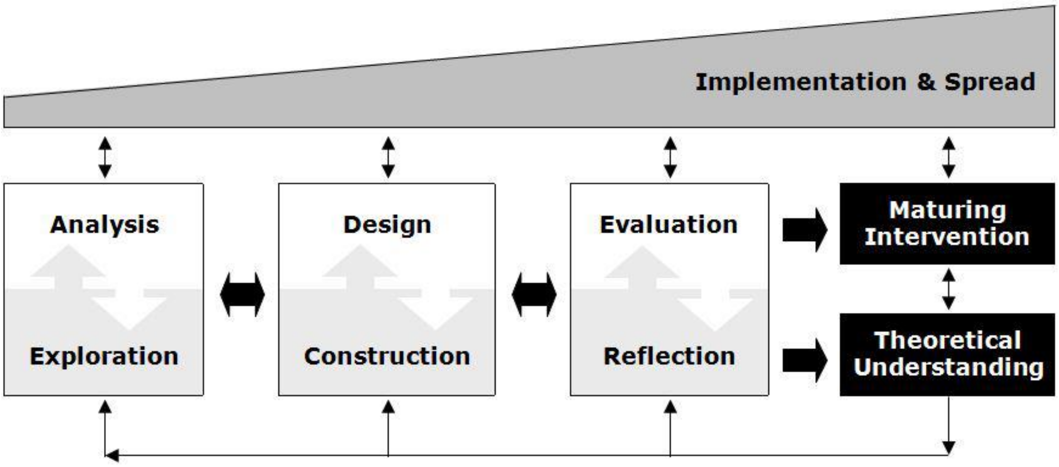

Figure 1. Generic model for conducting design research in education (McKenney & Reeves, 2012, p. 77)

1.2.1. Analysis and exploration

The purpose of the first phase was two-fold: reflecting the dual focus on theory and practice. The first goal of this phase was identification and conceptualization of the problem through *analysis*. As John Dewey (1938) pointed out "a problem well put is half-solved" (p. 108); because, if the problem is defined poorly, the subsequent inquiry would be irrelevant and off the track. Therefore, the definition of the problem has utmost importance for starting the research, especially, for such an intense multi-faceted study, EDR. McKenney and Reeves (2012) recommended three main processes to be followed in analysis, namely, *initial orientation*, *literature review* and *field-based investigations*.

Most of the time, researchers start to investigate the problems defined by the gaps in the literature, rather than defined by practice. In this dissertation, the problem was defined by the experience my supervisor, my personal research agenda, as well as literature review. My *initial orientation* to the study started with the weekly discussions with my supervisor based on her experiences in developing PSTs' SSI understanding in undergraduate course. She has been the instructor of the SSI course for more than a decade. She has been teaching SSI through readings and different activities in that course. As a part of that course, PSTs were also expected to select a topic from the science curriculum and critically analyze whether science, technology and society aspects of the topic were sufficiently presented in the curriculum through a provided rubric. In that course PSTs were also expected to find and present positive (supporting) and negative (opposing) evidences for the issue of nuclear power plant construction. In addition to these assignments, PSTs presented a case dilemma to the class as a group. By completing the requirements of the course, PSTs were engaging in discussions to understand the nature of SSI and the status of it in science curriculum. They were also experiencing how to learn SSI through case dilemmas and searching evidence. While implementing those activities in the course, the instructor has frequently benefited from different technologies. Moreover, PSTs were also encouraged to use technology in their research and case dilemma presentations. However, we decided that PSTs also need practices for teaching SSI that are enriched with effective technological tools. Moreover, we realized the contribution of technology in teaching SSI. Therefore, in order to develop PSTs' TPACK for effective SSI teaching, we decided to re-design this SSI teaching undergraduate course.

In addition to these insights gained from the weekly discussion with my supervisor about her experiences, my Master's thesis helped me to conceptualize this research. The purpose of the thesis was to investigate the status of pre-service science teachers' TPACK regarding genetics. For this purpose, a TPACK instrument was adapted to the genetic context consulting an expert committee. A different factor structure from the hypothesized theoretical one was reached in the factor analysis. The factors including the overlapping knowledge bases were loaded in single factor. This can be interpreted as the indicator of the transformative nature of TPACK. Therefore, necessity of considering TPACK as a different body of knowledge rather than the integration of the components of it was realized. Moreover, since we adapted the instrument into a specific subject matter area, genetics, the differences in the factor structure from the hypothesized one may also be arisen from the characteristics of the subject matter area. Therefore, having TPACK in general for science may not be the indicator of having TPACK for specific subject matter area. Moreover, the nature of the technology integration knowledge for different content areas might show differences. TPACK should be contextualized in specific subject matter areas in studies trying to determine and develop TPACK of PSTs. In this study, since we think that integrating technology would increase the effectiveness of SSI teaching, we decided to develop PSTs' TPACK for effective SSI teaching. By this way, we can reach conclusion about the nature of the knowledge required for technology integration into SSI teaching.

The other process followed in analysis phase was *literature review*. The role of the literature review in this phase was not to find the ways to solve the problem but to understand how the problem was experienced by others and to examine how and why these problems were examined (McKenney and Reeves, 2012). The insight gained from literature review helped me to conceptualize the problem, shape the design of the course in solving the problem, and determine the data collection and data analysis procedure congruent with the theoretical framework and the goals of this study. With these goals in mind, the relevant literature was reviewed in the analysis phase of this study.

After conceptualizing the problem and the context, a more open-ended *exploration* phase was put into place. The goal of this phase was to construct a richer understanding of the problem and the attempts to solve it. For this phase, McKenney and Reeves (2012) recommended three main strategies, which are *site visits, professional meeting,* and *networking*. Since the instructor of the re-designed course was my advisor and I had been working in the same department as teaching assistant, we had many opportunities to do site visits.

In order to seek the possible ways of solutions to the problem at hand, I attended to different conferences, such as National Association for Research in Science Teaching (NARST) Conferences held in Indianapolis in 2012 and Pittsburg in 2014; and International Society of Educational Research (iSER) 2014 World Conference held in Nevşehir, Turkey. At these conferences, I had the opportunity to discuss the details of the similar studies conducted by other researchers. Especially in the conferences I attended in 2014, I enlarged my network. I, further, discussed my research plan with the professionals I met at those conferences. These discussions helped me considerably especially in terms of the conceptualization of the problem. After the conferences, I contacted with those researchers via e-mail to get feedback about my theoretical framework and my operational definition of TPACK for effective SSI teaching and teacher metacognition. I sent a written document explaining my theoretical framework to an experienced researcher on teacher metacognition and two experienced researchers on TPACK to get feedback. Moreover, I discussed my proposal with my dissertation examining committee in the meetings. All these interactions with the professionals in the field helped me to make the problem clear, determine the design requirements and construct the initial design principles.

1.2.2. Design and construction

This phase of EDR included the exploration of potential solutions and checking the feasibility of the most promising solutions. The prototypes of the interventions, which tended to be incomplete in early versions and became more detailed and functional in later versions, were produced in this phase. This phase did not only include empirical data collection, but also cyclic processes of thought experiments to refine the solutions continuously (Gravemeijer & Cobb, 2006). Since this phase can be associated with the words of imagination and engineering which reflects the needs for both creative and analytical viewpoints, there are particular competencies for design and construction (McKenney & Reeves, 2012). This phase requires teamwork, communication, and creativity.

In this phase, ideas about solutions of the defined problem were generated and checked in collaboration with committee members to decide potential viability. A skeleton design and then detailed design specifications were set to specify the components of the intervention. After the specification of the components of the intervention, we started to prototyping process by building initial solutions. After two prototypes were constructed, the re-designed course was implemented with the help of a team including researchers, teachers, technical support center as well as pre-service teachers. Taking the evaluation and reflection findings reached during and at the end of the implementation into consideration, the solution was revised. Therefore, another prototype was constructed after the first implementation. The revised solution was again implemented in the next year.

1.2.3. Evaluation and reflection

In EDR, evaluation and reflection is not just an after-treatment phase performed at the end of the study. It includes a summative evaluation aiming to determine the actual effectiveness of the complete intervention as well as a formative evaluation aiming "to gain insight into the quality of tentative interventions and their design principles and to get revision decisions for developing the next—improved—prototypes" (Nieveen & Folmer, 2013, p. 158). Therefore, it is not a one-shot phase. In this dissertation, both formative and summative evaluation was performed to achieve different purposes.

Formative evaluation is defined in the context of EDR 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 & Folmer, 2013, p. 158). In order to design high-quality interventions, Nieveen and Folmer (2013) put forwards four quality criteria which are:

- Relevancy: There is a need for the intervention, and its design is based on state-of-the art (scientific) knowledge – also called content validity
- Consistency: The intervention is 'logically' designed – also called construct validity
- Practicality
  - Expected: The intervention is expected to be usable in the setting for which it has been designed
  - Actual: The intervention is usable in the setting for which it has been designed
- Effectiveness
  - Expected: Using the intervention is expected to result in desired outcomes
  - Actual: Using the product results in desired outcomes. (p. 160)

The present study was framed to meet these quality criteria. The research questions were written for each phase by considering the quality criteria appropriate for that phase.

Another evaluation conducted in this study was summative evaluation. The aim of this evaluation was to determine the actual effectiveness of the intervention. Whether the intended outcomes were reached through the intervention was tried to be decided. The summative evaluation was performed through utilizing qualitative data collection and data analysis tools.

Reflection in this phase does not imply the personal experiences as a researcher but refers to retrospective consideration of findings. Reflection can be termed in the context of EDR as "active and thoughtful consideration of what has come together in both research and development (including theoretical inputs, empirical findings, and subjective reactions) with the aim of producing new (theoretical) understanding" (McKenney & Reeves, 2012, p. 151). Therefore, reflection took place throughout the entire study by considering both the processes and findings.

The phases of the educational design research and the steps followed in the phases for this dissertation were briefly explained in this chapter. The detailed information about the design processes was presented in the following chapters.

1.3. Research Questions

As it was explained, formative evaluation was performed throughout the study according to the quality criteria defined by Nieveen and Folmer (2013) in all phases. Therefore, research questions concerning each phase and cycle was framed considering these quality criteria. Plomp (2013) suggested using the following syntax for phrasing the overall research question for the studies aiming to develop an innovative intervention "What are the characteristics of an <intervention X> for the purpose/outcome Y in context Z?" (p.27)

Pursuing this syntax, the overall research question of this study was stated as:

- What are the characteristics of an undergraduate course for developing pre-service science teachers' effective SSI teaching practices with technology by activating metacognition?

This study has three phases and eight cycles. Therefore, in addition to the overall research question, each phase has its own relevant research questions. The schematic representation of the phases and cycles with relevant research questions was presented in Figure 2.

In order to conduct a high-quality design research, the quality criteria suggested by Nieveen and Folmer (2013) were considered while developing the secondary research questions of each phases. There is a logical hierarchy among these quality criteria and different criteria should be emphasized in different phases of the design research (Nieveen & Folmer, 2013). Therefore, the criterion of *relevance* was considered in developing the research questions of the first phase. The criterion of relevancy, also called content validity, seeks for the justification of: “There is a need for the intervention, and its design is based on state-of-the art (scientific) knowledge” (Nieven & Folmer, 2013, p.160). For this purpose, the following two research questions were written for the first phase:

1. How are the pedagogy of effective SSI teaching, TPACK and teacher metacognition operationalized by researchers?
    a. What are the theoretical perspectives explaining the pedagogy of effective SSI teaching?
    b. What is the role of technology integration in effective SSI teaching?
    c. What are the available frameworks defining TPACK of (science) teachers?
    d. What are the available frameworks defining teacher metacognition?
2. What are the characteristics of a course to develop pre-service teachers’ effective SSI teaching practices with technology by activating their metacognition?
    a. How can pre-service teachers’ effective SSI teaching practices with technology be developed?
    b. How can metacognition of pre-service teachers be activated?

In order to address the first research question, the meaning of SSI and its place in science education was sought in the literature (See 2.1.1 Socio-Scientific Issues). Moreover, the role of technology integration in effective SSI teaching and the need for developing PSTs’ effective SSI teaching practices with technology was elaborated. Besides, an extensive literature review was conducted to come an understanding of what constitutes the TPACK and metacognition of science teachers (See 2.1.2 TPACK Frameworks and 2.1.3 Teacher Metacognition). Therefore, the purpose of this review was to investigate the theoretical basis of the study. Drawing from an understanding of this research question, a conceptual framework for this study was developed to inform the design and content of the re-designed course, as well as to guide the process of interpreting the results.

To address the second research question, another literature review was carried out to learn about the possible ways to develop PSTs' effective SSI teaching practices, to develop their TPACK, and to activate their metacognition. In the light of the findings of these two research questions, design principles were constructed to serve as a guide for design and construction. Moreover, the initial design prototypes were framed based on the findings of these literature reviews.

The purpose of the second phase of the study was to find efficient ways to develop PSTs' effective SSI teaching practices with technology by activating their metacognition. Therefore, for the next research question the criterion of *consistency* was taken into consideration. This criterion, which is also called construct validity, ensures that the intervention is 'logically' designed (Nieveen & Folmer, 2013). In this phase, an undergraduate course was tried to be re-designed in the light of the design principles obtained from the literature. Therefore, by considering the strengths and weaknesses of the available approaches, in order to develop PSTs' effective SSI teaching practices with technology, teaching and learning activities' consistency with design principles should be addressed. For the purpose of this criterion, the following research question was developed.

3. How consistent is the design of the course with the design principles to develop PSTs' effective SSI teaching practices with technology by activating their metacognition?

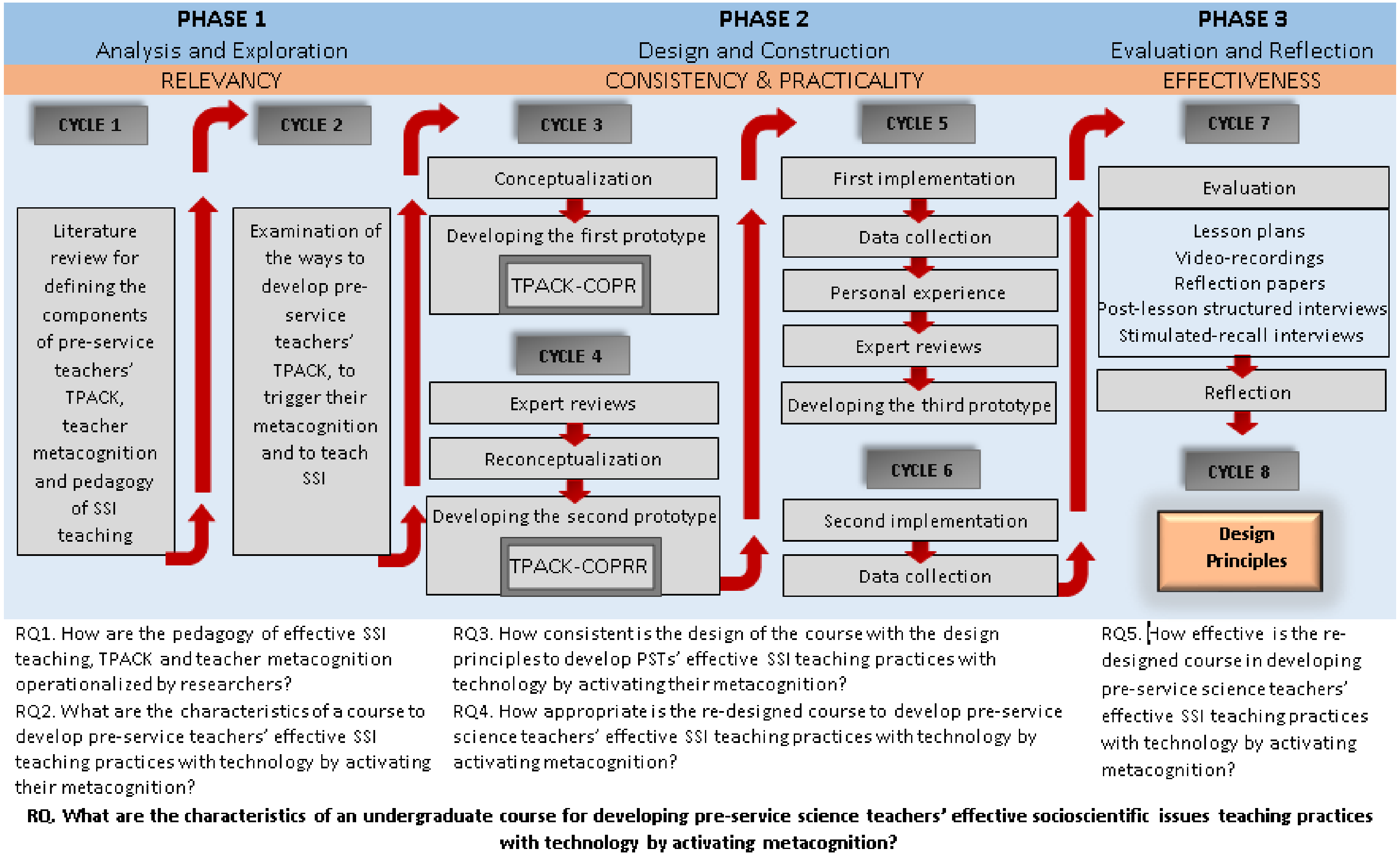

Figure 2. Design research model of this study (Adapted from Dowse & Howie, 2013, p.856)

Through iterative cycles of revisions in the light of expert reviews, experiences gained in implementation, pre-service teachers' reflections, and current literature, the most appropriate teaching and learning activities were decided to be included in the re-designed course. In order to answer this research question, the consistency of the stages of the re-designed course with the design principles was investigated. Therefore, the relationship between the design principles retrieved from the literature and the design of the course was explicated.

In order to be able to implement the intervention, its *practicality* needs to be established. Before implementing the intervention *expected* practicality which indicates "The intervention is expected to be usable in the setting for which it has been designed" (Nieveen & Folmer, 2013, p.160) should be emphasized. Then, the *actual* practicality needs to be determined after implementation to show the usability of the intervention for the setting in which the study has been designed. Therefore, perceived contribution of the activities conducted in the course was investigated to understand their practicality in developing PSTs' effective SSI teaching practices with technology. Moreover, reflecting on the practicality of the activities conducted in the course, the design principles and the content of the course was revised. The practicality of the study was addressed through the following research question.

4. How appropriate is the re-designed course to develop pre-service science teachers' effective SSI teaching practices with technology by activating metacognition?

The last research question was about the issue of praxis. When an intervention is put into practice, it is vital to determine to what extent the implementation is effective in reaching the expected outcomes. For this purpose, it is important to consider the quality criteria of *effectiveness* for the design. In this study, both the *expected* effectiveness: "using the intervention is expected to result in desired outcomes" and *actual* effectiveness: "using the product results in desired outcomes" (Nieveen & Folmer, 2013, p.160) were considered. Therefore, the next research question was written to seek for the indicators of effectiveness via formative and summative evaluations of the desired outcomes (See Chapter 4 and Chapter 5). Therefore, the final research question was formed to evaluate the re-designed course in terms of its effectiveness:

5. How effective is the re-designed course in developing pre-service science teachers' effective SSI teaching practices with technology by activating metacognition?
    a. What is the development of PSTs' effective SSI teaching practices throughout the course?
    b. What is the nature of PSTs' SSI teaching practices after they attended to the re-designed course?
    c. What is the pattern of PSTs' metacognition underlying their SSI teaching practices with technology?
    d. What is the relationship between the PSTs' effective SSI teaching practices with technology and metacognition patterns?
    e. What is the contribution of the re-designed course in the development of PSTs' effective SSI teaching practices?

1.4. Significance of the Study

This study was expected to yield both theoretical insights and practical contributions to the solution of the problem, which is developing PSTs' effective SSI teaching practices with technology by activating metacognition. In terms of practical contribution, the significance of this study lies in its contribution to the understanding of the ways to develop PSTs' effective SSI teaching practices. SSI topics are included in Turkish science curriculum and teachers are expected to teach science in the context of SSI. However, there are not much courses or professional development programs to help teachers or pre-service teachers learn how to teach SSI. Teacher education programs have crucial role in helping pre-service teachers move beyond transmissive orientations to teaching science through SSI teaching (Pedretti, 2003). Therefore, teacher education programs should assist pre-service teachers in significant and meaningful ways.

Technology was found to be important to increase the quality of SSI teaching. Therefore, PSTs should have the ability to select proper technologies and implement them in a way that increases the quality of their SSI teaching. For this reason, an undergraduate SSI teaching course was re-designed and refined in the light of the data gathered in the implementations to be a solution to the problem of PSTs' lack of knowledge and experience in teaching SSI with technology.

In terms of theoretical insights, the significance of the present study is its contribution to the understanding of the PSTs' effective SSI teaching practices with technology. Conceptualization of technology integration knowledge, called TPACK, regarding whether it is domain-general or domain-specific is a challenging issue in the literature. TPACK is a unique construct and there are three main characteristics of TPACK as a construct of teacher knowledge. As it was stated by Mouza (2011) "(a) It is highly situated, local and specific; (b) it is developed in practice in response to specific need; and (c) it is influenced by contextual factor" (p. 4). Technology use in the classroom needs to be dependent on subject matter together with other contextual factors; therefore, teachers should go beyond generic use of technology to be able to take advantage of the full potential of technology for teaching specific subject matter (Angeli & Valanides, 2009; Mishra & Koehler, 2006). For this reason, in order to help teachers to develop a deeper understanding of TPACK, teacher education programs need to situate technology knowledge required to teach within specific content (Mishra & Koehler, 2006).

There are some studies focusing on subject-specific TPACK (Jimoyiannis, 2010; Lin et al., 2013; Savaş, 2011). Review studies urge forthcoming studies on contextualizing TPACK in different subject matters in an appropriate level (Angeli et al., 2016; Voogt et al., 2013). Moreover, the effectiveness of the instruction with technology can be maximized by considering students' content-related learning needs in planning and selecting appropriate technologies which require content-based (and content-specific) pedagogical and technological knowledge (Harris, Mishra, & Koehler, 2009; Niess, 2005). Therefore, focusing on a specific subject matter area, socio-scientific issues, helped us to track the development of PSTs' knowledge on technology integration by considering the subject-specific needs of students pertaining to socio-scientific issues.

Moreover, by activating metacognition in the re-designed course, PSTs were guided to think about their thoughts in preactive, interactive and postactive stages of teaching. In this way, PSTs' considerations in these stages were tried to be revealed. Teacher metacognition is a relatively less considered area compared to the metacognition of learners. However, metacognition is important to explain thoughtful actions of teachers or pre-service teachers (Artz & Armour-Thomas, 1998; Hartman, 2001; Lin, Schwartz, & Hatano, 2005; McAlpine, Weston, Beauchamp, Wiseman, & Beauchamp, 1999; Yerdelen-Damar, Özdemir, & Ünal, 2015). Therefore, by activating and figuring out PSTs' metacognition, it was aimed to contribute to the theoretical understanding of teacher metacognition and the relationship of it with PSTs' effective SSI teaching practices with technology.

In order to reach the goals of this dissertation, educational design research was utilized since "by its nature, design research is relevant for educational practice (and therefore also for educational policy) as it aims to develop research-based solutions for complex problems in educational practice" (Plomp, 2013, p.17). Educational design research has the potential to bridge the gap between theory and practice in educational research and it is also appropriate for pre-service teacher development experiments (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). EDR is appropriate for open problems such as the situations when pedagogical content knowledge is poor, the instructional materials are poor or not available (Kelly, 2013). Since in our case, PSTs' SSI teaching practices and the instructional materials to develop PSTs' effective SSI teaching practices need to be improved, EDR was used to meet these needs.

1.5. The Theoretical Perspective Utilized in This Study: Social Constructivism

There are different theoretical perspectives about the ways of learning. Constructivism is one of the most influential learning theories in science education (Arslan, 2007; Matthews, 1997). Constructivism has influence on teacher education and pedagogy in science education (Matthews, 1997), since constructivism is considered as a major philosophical referent for the reforms of science education (Bentley, 1998; Tobin &

Tippins, 1993). It has also a considerable influence on science education reforms in Turkey since 2004 (Ünder, 2010). There are varieties of constructivism including educational constructivism, philosophical constructivism and sociological constructivism. Educational constructivism draws upon other varieties of constructivism (Matthews, 1997) and it has its roots in the theories of educational psychology. As the label implies, in each varieties, constructivism deals with the construction of meanings (Bentley, 1998).

In education, constructivism is categorized in three general categories, which are pedagogical, psychological, and epistemological (Ünder, 2010). Constructivist pedagogy offers suggestions for teachers about how to help students develop genuine understanding (Ünder, 2010) and it is favored in science education (Matthews, 1997). As opposed to the teacher-oriented transmission model, which emphasizes content excessively, facilitates passive rote learning without genuine understanding, constructivist pedagogy starts with a recognition that each students' knowledge is constructed with his experiences (Irzik, 2001). Therefore, any constructivist teacher should be open to listen to students and try to reveal individual learning needs. Teachers need to help students disclose their own ideas about a particular topic clearly, so that they become aware of others' thoughts and can negotiate their ideas with other students. That is, in constructivist pedagogy, teachers were advised to make students active in their learning process, consider students' prior knowledge and interests, diagnose students' misunderstanding for remediating, and emphasize understanding and reasoning (Ünder, 2010).

Although constructivism as pedagogy is criticized for being reduced to a set of methods that are not new for science education (Ünder, 2010), constructivism as a learning theory provides explanations for the ways of learning and helps us understand students' meaning making through their experiences (Tobin & Tippins, 1993). Constructivism as learning theory is based on psychological theories including the learning theories of Piaget and Vygotsky. Although all constructivists acknowledge the learner's active role in knowledge construction, there are different theoretical positions about constructivism on a continuum, which are cognitive constructivism, radical constructivism, and social constructivism.

Cognitive constructivism relies on Piaget's constructivist theory of cognitive development and cognition, and it is defined as "the view that individual cognitive agents understand the world and make their way around in it by using mental representations that they have constructed." (Grandy, 1997, p.114). Radical constructivism is positioned at the opposite end of the continuum from cognitive constructivism. Radical constructivists argue that although an external reality may exist, it is unknowable to the individuals; therefore, internal knowledge does not match external reality (von Glaserfeld, 1995). Social constructivism can be positioned between the cognitive constructivist, claiming the transmission of knowable reality, and the radical constructivism, claiming personal construction of reality. Social constructivist learning theory based upon the Vygotsky's theory. Vygotsky (1978) emphasized the role of the environment on learning by considering knowledge as a social and cultural entity. Social constructivists support collaborative meaning construction in learning communities and view knowledge as 'distributed' and 'shared' rather than an individual property of the learners (Duit & Treagust, 1998). According to this view, individuals cannot learn in isolation from the social context, because they are active agents of the society.

Vygotsky (1978) was the first modern psychologist who suggested the mechanisms of how culture becomes a part of individual's nature by explaining the interaction between learning and development. According to him, learning depends on the development of the child, but the reverse is not necessarily the case. Learning cannot be equated to development; however, "properly organized learning results in mental development and sets in motion a variety of developmental processes that would be impossible apart from learning" (Vygotsky, 1978, p.90).

Vygotsky (1978) claimed that students start learning before coming to the school. He argued that the contribution of the school learning into child's development can be explained with a new and important concept, called Zone of Proximal Development (ZPD). Vygotsky (1978) defined ZPD as "the 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" (p. 86). Therefore, according to this definition the development in children includes not only their individual learning but also their interaction with the external world. Therefore, based on Vygotsky's (1978) explanations of learning, social constructivist learning theory suppose that knowledge is not independent of context, rather it is constructed in interaction with society.

In this study, social constructivism was utilized due to its parallelism with the goals of SSI education and with the methods of teacher education. The relationship of social constructivism with SSI education and teacher education was explained in below sections.

1.5.1. Social contructivism and SSI education

As Oldfather, West, White and Wilmarth (1999) emphasized, "theories have a profound influence on the ways we conceptualize our roles, interact with students, develop and enact curriculum, and organize classroom" (p. 8). Social constructivist learning theory shows parallelism with the goals of teaching science in SSI context. Social constructivists have broader goals than the curricular goals and aim to develop students' self-knowledge, identities and beliefs about their role in making difference in the world (Oldfather et al., 1999). Similarly, by engaging students in learning science in SSI context, we aim to address citizenship education (Ratcliffe & Grace, 2003) and to contribute personal and social identity formation of students (Zeidler et al., 2005).

The emergence of SSI framework beyond STS education was justified with the lack of the emphasis on the quality of social interactions and reflective discourse in STS approach (Zeidler & Sadler, 2008; Zeidler et al. (2005). Zeidler et al., (2005) suggested a social constructivist view of contextual values for evaluating scientific knowledge claims, because acknowledging the importance of contextual values, social constructivist view help citizens evaluate scientific knowledge claims by providing accessible standards (Bingle & Gaskell, 1994). Although STS approach emphasized students' understanding of the interactions among, science, technology, and society, in SSI movement, students are confronted with moral problems including different scientific, social or moral viewpoints. Thus, they were expected to engage in knowledge formation through social knowledge construction and discourse, so that knowledge becomes relevant and socially shared (Zeidler et al., 2009).

Moreover, Zeidler et al. (2005) emphasized the importance of developing students' views about science through argumentation. Argumentation was considered as important for engaging students in co-construction of knowledge claims (Erduran, Simon, & Osborne, 2004). Therefore, engaging students' in argumentative discourse in SSI context ensures a social constructivist learning practice. Similar to Vygotsky's argument, children learn science in their daily life when they faced with scientific issues related to the society. However, by engaging children in scientific and moral discourse guided by the teacher in the context of SSI, their cognitive and moral development can be facilitated. To conclude, the principles of social constructivist learning theory coincide with the goals of teaching science in SSI context. Therefore, this study is grounded on the social constructivist learning theory.

1.5.2. Social constructivism and teacher education

Social constructivism was suggested to provide ground and direction for effective professional programs (Wang & Ha, 2012). It has also gaining importance in teacher education programs that see learning as socially constructed process (Rodriguez, 2005). Teacher education programs also decide their curriculum based on different epistemological views of teacher knowledge that are integrative and transformative.

The two different epistemological stances, namely, the integrative and transformative view of teacher knowledge have shaped the discussions about the nature of teacher knowledge required for technology integration, called TPACK, and development of the teacher knowledge. A similar difference in epistemological stances about PCK was also a concern in PCK literature. While integrative PCK model assumes the integration of knowledge bases into PCK, other model assumes the transformation of knowledge into distinct form of knowledge. Gess-Newsome (1999) discussed both views of PCK for teacher cognition on a continuum by providing implications for teacher preparation.

At one end of the continuum, PCK was defined as the teacher knowledge that can be explained by the intersection of three constructs, which are subject matter, pedagogy, and context, and it was defined as integrative model (Gess-Newsome, 1999). Similarly, Koehler and Mishra (2008) conceptualized the TPACK as an integrative body of knowledge, which includes the three basic knowledge domains, technology, pedagogy, and content, and the knowledge domains arising from the intersection between and among them. Technological pedagogical knowledge (TPK) arises from TK and pedagogy knowledge (PK); technological content knowledge (TCK) occur at the intersection between TK and CK; pedagogical content knowledge (PCK) emerges at the intersection of PK and content knowledge (CK); and technological pedagogical content knowledge (TPACK) is originated from the intersection among TK, PK and CK. According to this view, these knowledge dimensions are in a dynamic equilibrium and "a change in any one of the factors has to be 'compensated' by changes in the other two" (Mishra & Koehler, 2006, p.1029).

For teacher education programs based on integrative model, Gess-Newsome (1999) emphasized the need for deep and flexibly organized understanding of the subject matter, pedagogy, and context, together with the necessary tools for integrating these knowledge bases in practice. In teacher education programs holding this view, knowledge bases can be taught separately or in an integration manner. In this view, fostering integration skills is considered as vital for teacher education programs. Similarly, Mishra and Koehler (2006) proposed *learning by design* approach to develop pre-service teachers' TPACK (See 3.1.3.2 Learning by design approach). By designing an instructional material, pre-service teachers get involved in a cyclic process of defining, designing and refining the materials within different contexts. TPACK development through this model requires teachers to integrate different knowledge domains dynamically by interweaving them.

At the other end of the continuum, from a transformative view, PCK was defined as the synthesis of all necessary knowledge to be an effective teacher (Gess-Newsome, 1999). The transformative model of PCK assumes a new and only form of knowledge affecting the teaching practice occurring with the transformation of subject matter, pedagogical, and contextual knowledge. Similarly, recent research evidences in

TPACK field indicate that TPACK is transformative, rather than integrative (Angeli et al., 2016). Niess (2015) stated the nature of TPACK as “a new and distinct form of knowledge, where these subsets have been rearranged, merged, organized, assimilated, and integrated, such that none are individually discernible, and, in fact, have been transformed into something new.” (p. 34). There are different transformative TPACK frameworks assuming a unitary holistic body of knowledge (Angeli & Valanides, 2009; Niess, 2005, 2015; Yeh, Hsu, Wu, Hwang, & Lin, 2014). Angeli and Valanides (2009) defined their transformative ICT-TPCK framework as:

> Knowledge about tools and their pedagogical affordances, pedagogy, content, learners, and context are synthesized into an understanding of how particular topics that are difficult to be understood by learners, or difficult to be represented by teachers, can be transformed and taught more effectively with ICT, in ways that signify the added value of technology. (pp. 158-159)

Gess-Newsome (1999) suggested teacher education program based on transformative model to identify exemplars of PCK and their conditions for use. The main focus of teacher education programs holding this view is to teach the examples of PCK and selection criteria for these examples. As Gess-Newsome (1999) argued, teaching PCK by providing the best practices results in quicker development of teacher candidates’ skills and knowledge needed to be effective teachers. The researcher stated that the current teacher education programs that are based on integrative view had not produced the desired results; however, the transformative model has potential to provide solutions to the dilemmas of integrative model.

In transformative TPACK view, it was assumed that “teachers’ TPACK transforms with experiences on designing and delivering content instruction with appropriate uses of technology and that it is the way teacher educators should follow to develop their students’ TPACK.” (Hsu, 2015, p.9). The researchers argued that trying to develop teachers’ TPACK from an integrative perspective assuming that TPACK is a body of knowledge that “emerges spontaneously on the spot” causes in failure to develop an understanding of the complex interactions among technology, subject matter and pedagogy (Angeli et al., 2016). Teacher education programs were criticized for the way of teaching method, content and technology courses in isolation resulting in the development of a body of fragmented teacher knowledge (Angeli et al., 2016; Angeli & Valanides, 2009; Niess, 2005). Research has shown that development in one knowledge domain does not necessarily give rise to TPACK development (Angeli & Valanides, 2005; 2009; Valanides & Angeli, 2006). Angeli et al. (2016) argued that TPACK cannot be an integrated body of knowledge, and any growth in individual knowledge bases does not necessarily result in TPACK growth.

As it can be clearly understood from the suggestions of Gess-Newsome (1999) for teacher knowledge development, the main difference of transformative view from integrative view was the emphasis on the context. Gaining theoretical knowledge about content, pedagogy and technology cannot guarantee effective teaching. In order to develop pre-service teachers' knowledge, they should be given chance to learn from their own practices in the social context and from others' practices. Gess-Newsome (1999) suggested the identification of outstanding examples of PCK in action for teacher education programs that support transformative model. This suggestion is in line with the thoughts of social constructivists. By providing pre-service teachers best practices of science teaching, they can be given chance to develop their pedagogical content knowledge through collaboration of more capable peers or more experienced teachers. Therefore, congruent with the social constructivist view, the nature of TPACK of pre-service science teachers was viewed as transformative in this study. Thus, the suggestions provided in the literature for developing TPACK from transformative perspective was regarded in developing PSTs' knowledge for effective SSI teaching with technology. The theoretical framework explaining the knowledge dimensions of TPACK for effective SSI teaching were explained in the next chapter.

1.6. Definitions of the Terms

Socio-Scientific Issues: Socioscientific issues (SSI) are controversial scientific topics that involve social and ethical considerations (Sadler, 2004a). Topics stem from dilemmas involving biotechnology, environmental problems and human genetics such as cloning, stem cells, genome projects, global warming, and alternative fuels, can be given as the most common examples to SSI.

Technological Pedagogical Content Knowledge (TPACK): "A dynamic framework for depicting the knowledge teachers rely on to design and implement curriculum and instruction, as they guide students' thinking and learning with digital technologies in various content areas" (Niess, 2013, p. 174-175). There are four central components of it: an overarching conception of what it means to teach with technology, knowledge of students' thinking and understandings of specific topics with technologies, knowledge of curricular materials that incorporate technologies, and knowledge of instructional strategies and representations for teaching subject matter with technologies.

Teacher Metacognition: The thinking processes that teachers use in making decisions and judgments before (*planning*), during (*monitoring* and *regulating*), and after (assess*ing* and revising) a lesson (Artzt & Armour-Thomas, 1998) and knowledge about their knowledge of content and pedagogy.

Educational Design Research: "A genre of research in which the iterative development of solutions to practical and complex educational problems also provides the context for empirical investigation, which yields theoretical understanding that can inform the work of others" (McKenney & Reeves, 2012, p.7).

1.7. Organization of the Chapters in the Dissertation

This dissertation was organized in a relatively different format due the characteristics of education design research studies. The content of each chapter and the products of the cycles of the EDR were summarized in Table 1.

In Chapter 1, the need for the study was tried to be explained. Then, the theoretical frameworks utilized for the conceptualization of teacher knowledge required for effective SSI teaching, technology integration and teacher metacognition was explained. The research questions were written considering the quality criteria defined for EDR studies. Therefore, in order to increase understandability of the design research model (Figure 2) and the research questions written for different phases of the study, a brief explanation about the research design overview was provided.

Chapter 2 included the first phase of the EDR which was based on literature review. In this chapter, a comprehensive literature review was provided. As the outcome of this phase, theoretical framework of this dissertation and the initial design principles guiding the next phase of the study was determined.

Table 1
Summary of the Content of the Chapters

Chapters and phases of EDR	**Cycles of EDR**	**Products of the Cycles**
Chapter 2: Phase 1 (Analysis and Exploration)	**Cycle 1:** Operationalization of the Constructs	Theoretical framework of the dissertation - SSI Teaching Framework (Sadler et al., 2007; Zeidler et al., 2005) - TPACK framework (Magnusson et al., 1999; Niess, 2005) - Teacher Metacognitive Framework (Artzt & Armour-Thomas, 1998)
	Cycle 2: Determining the Characteristics of the Course Design	Initial Design Principles (DPs) - DP1: PSTs should be guided to select an SSI topic relevant and meaningful to teach and learn. - DP2: PSTs should be guided to consider the role of students' epistemological views including NOS beliefs in their decision-making in SSI. - DP3: PSTs should be guided to create learning environments that facilitates the construction of shared social knowledge via discourse about SSI. - DP4: PSTs should be guided to include moral and ethical dimensions into their SSI teaching. - DP5: Concepts and theories about the pedagogy of SSI teaching and technology integration should be discussed explicitly. - DP6: Attempts to develop PSTs' effective SSI teaching with technology should align theory and practice. - DP7: PSTs should be facilitated to collaborate with peers. - DP8: PSTs should be provided role models of effective SSI teaching with technology. - DP9: PSTs should be scaffolded in their SSI teaching with technology experiences. - DP10: PSTs should be engaged in critical reflection about their technology-integrated SSI teaching practices. - DP11: PSTs' metacognition about their technology-integrated SSI teaching practices should be activated by stating the effects of being engaged in metacognitive processes on their development explicitly. - DP12: PSTs' effective SSI teaching practices with technology can be developed by engaging them in design process.

Table 1
Summary of the Content of the Chapters (continued)

Chapters and phases of EDR	**Cycles of EDR**	**Products of the Cycles**
Chapter 3: Phase 2 (Design and Construction)	**Cycle 3:** Developing the First Prototype	First Prototype of the Course and DPs Related to the Stages of the Course - Comprehension Stage: DP1, DP2, DP3, DP4, DP5, DP6, DP7, DP11 - Observation Stage: DP8 - Practice Stage: DP6, DP7, DP9, DP12 - Reflection Stage: DP10
	Cycle 4: Developing the Second Prototype	Second Prototype of the Course and DPs Related to the Stages of the Course - Comprehension Stage: DP1, DP2, DP3, DP4, DP5, DP6, DP7, DP11 - Observation Stage: DP8 - Practice Stage: DP6, DP7, DP9, DP12 - Reflection Stage: DP10 - Revision Stage: DP13 Added Design Principle - DP13: PSTs should be given opportunity to revise and adapt their knowledge for effective SSI teaching with technology.
	Cycle 5: Developing the Third Prototype of the Course	Third Prototype of the Course and DPs Related to the Stages of the Course - Comprehension Stage: DP1, DP2, DP3, DP4, DP5, DP6, DP7, DP11 - Observation Stage: DP8, DP14 - Practice Stage: DP6, DP7, DP9, DP12 - Reflection Stage: DP10 - Revision Stage: DP13 Revised Design Principle - DP8: PSTs should be provided role models of effective SSI teaching with technology, which shows similarity with them. Added Design Principle - DP14: Teacher educators should provide explicit modeling about their own technology integration into SSI teaching practices.
	Cycle 6: Implementation of the Last Prototype	Data Obtained from the Second Implementation
Chapter 4, 5: Phase 3	**Cycle 7:** Evaluation and Reflection	Results of the data analysis
Chapter 6: Phase 3	**Cycle 8:** Design Principles	Final Design Principles

In Chapter 3, the methodology of the dissertation was explained. The research paradigm of the study and the characteristics of EDR in relation to the characteristics of the current study were explicated. Moreover, data generation and data analysis methods were described by addressing the trustworthiness and ethical issues. Chapter 3 was organized to provide the details of second phase of the EDR. In the second phase (Design and Construction), the prototypes of the re-designed course were provided. Reflections to each prototype were also given after the explanation of the prototypes.

The third phase of the study was evaluation and reflection. Since the formative assessment was carried out throughout the study, it was not repeated in this section. Moreover, the results of the summative evaluation were reported in the following chapters. Chapter 4 included the results about PSTs' development of effective SSI teaching practices with technology. The next result chapter, Chapter 5, was composed of the findings about the metacognition of PSTs underlying their instructional practice. Moreover, the differences in PSTs' TPACK for effective SSI teaching with different metacognitive patterns were also explained in that chapter. The final design principles were included in the last chapter. Then, the implications were provided for researchers and practitioners.

CHAPTER 2

LITERATURE REVIEW

As it was mentioned in the research design overview, the first phase of the educational design research included literature review for two different purposes. The first phase of the EDR, called analysis and exploration, included two cycles. In the first cycle, the problem was defined based on the literature. Then, the theoretical framework of the study was established. In the second cycle, the literature about effective SSI teaching, TPACK development and metacognition training were reviewed. Based on the possibilities and difficulties of the available methods, characteristics of an effective course to develop PSTs' effective SSI teaching practices through technology integration by activating their metacognition were determined.

2.1. Cycle 1: Operationalization of the Constructs

This cycle was conducted to define the problem and establish the theoretical framework of this dissertation. Therefore, the following research question and the sub-questions were tried to be answered.

1. How are the pedagogy of effective SSI teaching, TPACK and teacher metacognition operationalized by researchers?
    a. What are the theoretical perspectives explaining the pedagogy of effective SSI teaching?
    b. What is the role of technology integration in effective SSI teaching?
    c. What are the available frameworks defining TPACK of (science) teachers?
    d. What are the available frameworks defining teacher metacognition?

2.1.1. Socio-scientific issues

Socioscientific issues (SSI) are the dilemmas in which both society and science play an important role (Sadler, 2004a). SSI are open-ended problems which do not have clear-cut solutions. There can be multiple plausible solutions to SSI that are not necessarily determined by scientific considerations (Sadler, 2011). Although science and society are inseparable from each other, these issues arouse more societal interest, affect and consequence. The technological developments, which affect society closely, such as constructing a nuclear power-plant, gene cloning, and tissue transplant, can be given example to these kinds of issues. The issues are influenced by different societal factors including politics, economics and ethics (Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007; Sadler, 2011). Incorporating SSI in science teaching have crucial role in raising responsible citizens (Kolstø, 2001).

2.1.1.1. Framework for teaching SSI

By engaging students in socioscientific inquiry, students are expected gain different knowledge and skills. Sadler and Dawson (2012) summarized the key learning outcomes of learning science in the context of SSI as developing understanding of science and nature of science, increasing motivation and interest, and supporting argumentation practices. First, students can learn science content in the context of SSI. There are empirical studies indicating increased performance in content learning when students are enrolled in science learning through SSI context (Klosterman & Sadler, 2010; Zohar & Nemet, 2002). In their review of empirical studies, focusing on the outcomes of SSI teaching interventions, Sadler and Dawson (2012) reached a conclusion that student can learn science in SSI-related interventions.

Moreover, SSI also provides a fruitful context for developing NOS understanding of students (Khishfe & Lederman, 2006). Walker and Zeidler (2007) investigated the NOS beliefs high school students hold in web-based SSI teaching intervention. The researchers found that students developed NOS ideas about tentative, creative, subjective, and social aspects of science. However, they also found that students could not reflect their NOS ideas in their decision-making during discussions. Based on

Abd-El-Khalick's (2003) suggestions about the possible interaction between epistemological stances and NOS aspects related to the discourse about SSI, Zeidler et al. (2009) investigated the effect of SSI teaching on personal epistemological growth. The researchers concluded that high school students' prolonged engagement into the SSI-based anatomy and physiology course stimulated their epistemological development.

Several SSI researchers and advocates claimed that learning science in socially relevant contexts, like SSI, increase interest and motivation level of students (Sadler & Dawson, 2012). In many empirical studies, students stated the personal and global relevance of the issues and reported that learning science in the context of SSI was more interesting and motivating (Bulte, Westbroek, Jong, & Pilot, 2006; Dori, Tal, & Tsaushu, 2003). Research also showed that SSI teaching interventions fostered positive attitudes of students toward science (Yager et al., 2006).

Another outcome of SSI education was frequently stated as the development of argumentation practices (Sadler & Dawson, 2012). Since SSI consist ill-structured and open-ended real world problems, they provide a productive medium of argumentation. Empirical studies showed that argumentation skills of the students in the SSI-teaching interventions clearly increased (Dawson & Venville, 2010; Tal & Kedmi, 2006; Zohar & Nemet, 2002). The quality of the arguments, the number of justification used, and the ability of considering multiple perspective and ethical issues were found better in SSI teaching interventions. The researchers argued that reason of these better performances lied in the context and relevance of the SSI and accordingly, higher levels of interest and motivation for engaging argumentation (Von Aufschnaiter, Erduran, Osborne, & Simon, 2008; Dawson & Venville, 2010).

In order to guide teachers to prepare effective science lessons in SSI context to reach the expected outcomes of SSI teaching mentioned above, there should be a clear theoretical perspective. For this purpose, Zeidler et al. (2005) proposed a research-based framework for SSI education. The SSI framework emphasizes four areas of pedagogical importance central to the teaching of SSI: (1) nature of science issues, (2) classroom discourse issues, (3) cultural issues, and (4) case-based issues (Zeidler et al., 2005). These issues aims to promote students' intellectual development and, in turn, their scientific literacy.

Nature of science issues reveals the importance of students' epistemological beliefs in decision making in SSI. Since decision making of students in SSI resembles the decisions of scientists on a scientific knowledge, in both cases epistemological orientations including NOS views have role in evaluating the scientific data. By using SSI context in science teaching, students' reasoning skills can be improved.

Classroom discourse issues focus mainly on the role of discourse on peer interaction and reasoning in SSI. Research studies showed the vital role of argumentation in creation of shared social knowledge about SSI (Zeidler, Osborne, Erduran, Simon, & Monk, 2003). Therefore, argumentation is the suggested pedagogy in SSI teaching.

Cultural issues indicate the diversity of the students in the classroom in terms of cultural background. Students' reasoning patterns can be affected from their cultural background or individual differences. Therefore, teachers should recognize the cultural diversity when addressing SSI in the classroom.

About case-based issues, teachers should select fruitful SSI topics in terms of fostering critical thinking skills, moral and ethical development. The inclusion of the issues into science teaching should have potential to make students engaged in discourse and reflection so that contribute to their cognitive and moral development (Zeidler et al., 2005).

In addition to these learning outcomes, SSI can serve as a vehicle for addressing citizenship education (Zeidler et al., 2005). In order to specify how this can be accomplished, Sadler, Barab and Scott (2007) introduced the theoretical construct of SSI reasoning. According to the researchers, decision-making in SSI context requires to include the following four practices:

(1) Recognizing the inherent complexity of SSI.
(2) Examining issues from multiple perspectives.
(3) Appreciating that SSI are subject to ongoing inquiry.
(4) Exhibiting skepticism when presented potentially biased information. (Sadler et al., 2007, p. 374)

Firstly, teachers should help students to recognize the complexity of SSI. Students' perception of SSI complexity is the desired outcome. Therefore, in SSI reasoning practices, teachers should guide students to approach an SSI context by considering multiple dynamic interactions of the factors involved in SSI (Sadler et al., 2007).

Moreover, SSI reasoning practices require acknowledging the existence of multiple perspectives. Students should recognize the perspectives other than their own standpoint and critically evaluate arguments of each perspectives. At this point, argumentation was considered as one of the most appropriate pedagogy for helping students to gain these skills, because argumentation provides productive pedagogy and assessment scheme for considering counter-arguments from multiple perspective and providing rebuttals for these counter-arguments (Erduran et al., 2004).

Social and scientific dimensions of SSI provide possibilities for inquiry and effective practices aiming SSI reasoning should provide SSI contexts open to both social and scientific inquiry. Congruent with the required thinking style in inquiry, students should be skeptical about the sources of information in SSI reasoning. Since there are multiple perspectives in SSI, students should be aware of the potential biases caused from the distortion of data from a particular perspective. They should not accept any information without analyzing it for possible bias. Therefore, teachers should guide students to gain this habit of mind.

Simmon and Zeidler (2003) provided suggestion for teachers to guide them about how to prepare lessons using SSI. Firstly, teacher should select a developmentally appropriate issue for students. After choosing the topic, teachers are advised to assess students' opinions about the topic. Then, in order to ensure a lively classroom discussion, teacher should guide the discussion, assist students in clarifying their positions, and facilitate student to explore the issue. Afterwards, teachers should ask students to write their position statements with supporting evidences. With a mock science conference, students can vote to reach a classroom decision. About NOS emphasis, teacher should inform students about the resemblance of this activity to real scientific community. Moreover, the researchers advised to include guest speakers in the lesson. This exemplar lesson flow can serve as a good example to see how SSI teaching can be.

2.1.1.2. The role of technology in SSI teaching

Technology integration was found to be influential in SSI teaching in many respects to reach the expected outcomes of SSI teaching. In comprehending the scientific background of the SSI, simulations can be considered as useful tools (Lee, 2007). Moreover, mobile augmented reality technologies can also be used to promote students' understanding of content (Chang et al., 2013). These augmented reality technologies also enhance learners' sense of presence by making it possible for students to be in the place mentioned in the SSI context. Combining the physical and virtual objects in the activities, teachers can help students feel a sense of closeness to the SSI (Chang et al., 2013). Besides helping students to comprehend scientific knowledge, ICT-mediated argumentation settings also help teachers to gain a deeper understanding of students' meaning making of SSI (Furberg & Ludvigsen, 2008). This gained insight about students' meaning making can be used as a starting point to scaffold SSI argumentation.

Technology has also great potential in terms of argumentative processes in SSI teaching. Scaffolding students' argumentation about SSI in creating claims based on presented evidence, evaluating the quality of evidence and engaging the argumentation process influence their argument evaluation ability (Belland et al., 2015). The argumentation scaffolding can be made more effective with the help of technological tools. Belland et al.'s (2015) study indicated that using computer-based scaffolding in SSI teaching resulted in the increase in argument evaluation quality of lower-achieving students.

McAlister, Ravenscroft and Scanlon (2004) argued that guiding student dialogue through synchronous online peer discussion resulted in improvements in students' argumentation and collaborative knowledge development. Ben-Horin, Pion and Kali (2017) investigated the effect of another online tool, Web-based Inquiry Science Environment (WISE), on socio-scientific reasoning through design-based research. They came up with an increased scientific understanding of students, but their SSI reasoning did not improve. However, since they revealed the effect of the module in increasing students' internal-values of learning, they decided to refine the module for further iterations based on the assumption that students' internal-values of learning is important for performing socioscientific inquiry.

These studies showed the potential of technology in fostering students' content learning, SSI reasoning and argumentation. To take the full advantage of technology in SSI teaching, teachers should have ability to integrate technology in SSI teaching. Since technology integration brings challenges along with its advantages for teachers, they should be trained for helping them to develop necessary skills for considering and overcoming these challenges effectively. There is a body of literature investigating the necessary knowledge and skills that a teacher should possess for effective technology integration. In the next section, the frameworks explaining the teacher knowledge for effective technology integration were explained.

2.1.2. TPACK frameworks

At the beginning of 21st century, several studies published concurrently (Angeli & Valanides, 2005; Guerrero, 2005; Gunter & Baumbach, 2004; Hughes, 2004; Koehler et al., 2004; Koehler & Mishra, 2005a; 2005b; Mishra & Koehler, 2003, 2006; Niess, 2005; Pierson, 1999, 2001) to emphasize the technology knowledge as an important component of teacher knowledge for effective technology integration. The current conceptualization of teacher knowledge for technology integration, called TPACK, has been emerged with a series of studies (Angeli & Valanides, 2005; Koehler & Mishra, 2005a; 2005b; Koehler & Mishra, & Yahya, 2007; Mishra & Koehler, 2006; Niess, 2005). This conceptualization of teacher knowledge for technology integration gave new direction to the research conducted about teacher knowledge. Although they were of the same mind about the importance of teachers' technology knowledge, the researchers used different frameworks and labeling in explaining the knowledge required for technology integration as it was summarized in Table 2.

Table 2
Studies Explaining TPACK Frameworks

Authors	Framework	Components of TPACK
		Integrative frameworks
Koehler & Mishra (2006)	TPACK	TK, PK, CK, TPK, TCK, PCK, TPACK
Jimoyiannis (2010)	TPASK	PSK (Pedagogical Science Knowledge), TSK (Technological Science Knowledge) TPK (Technological Pedagogical Knowledge) TPASK (Technological Pedagogical Science Knowledge)
Lee & Tsai (2010)	TPCK-W	Web-CK (WCK), Web-PK (WPK), Web-PCK (WPCK)
Benton-Borghi (2013)	UDL infused TPACK	UDL Infused PCK, UDL Infused TCK, UDL Infused TPK
Ling Koh et al. (2014)	TPACK-in-action	TK, PK, CK, TPK, TCK, PCK, TPACK, Teacher's design capacity Intrapersonal contextual factors Interpersonal contextual factors Cultural/ institutional contextual factors Physical/ technological contextual factors
		Transformative frameworks
Angeli & Valanides (2005)	ICT-Related PCK	1. Knowledge about how to identify topics to be taught with ICT 2. Knowledge about how to identify representations to transform the content 3. Knowledge about how to identify teaching strategies 4. Knowledge about how to select ICT tools to afford content transformations and support teaching strategies 5. Knowledge about how to infuse ICT activities in classroom instruction
Niess (2005)	TPACK	1. An overarching conception about the purposes for incorporating technology in teaching subject matter topics. 2. Knowledge of students' understandings, thinking, and learning in subject matter topics with technology. 3. Knowledge of curriculum and curricular materials that integrate technology in learning and teaching subject matter. 4. Knowledge of instructional strategies and representations for teaching and learning subject matter topics with technologies.
Kabakci-Yurdakul et al. (2012)	TPACK-deep	Design, Exertion, Ethics, Proficiency
Porras-Hernandez & Salinas-Amescua (2013)	ICT-Related PCK	TK, CK, PK, Knowledge of students, Teacher's self-knowledge, Micro-level context, Meso-level context, Macro-level context
Yeh et al. (2014)	TPACK-Practical	Knowledge of learners: a. Using ICT to understand students Knowledge of curriculum design: b. Using ICT to understand content, c. Planning curriculum, d. Representations, e. Teaching strategies Knowledge of classroom instruction: f. Instructional management, g. Teaching practices Knowledge of learners: h. Assessment

One of the differences in conceptualization of TPACK stemmed from the epistemological stance the researchers took. While some of the researchers view TPACK as an integrated knowledge, others view it as a transformative knowledge. This debate comes from the discussions about what constitutes PCK as it was explained in the first chapter.

From integrative perspective, TPCK framework was introduced building upon the two knowledge bases -content and pedagogy- of Shulman's (1986) PCK notion by adding a third knowledge base, technology (Koehler & Mishra, 2005a; 2005b; Mishra & Koehler, 2006). In this conceptualization of TPCK, there were seven knowledge domains, namely, (a) content knowledge (CK), which is the knowledge about subject matter that is to be learned or taught, (b) pedagogical knowledge (PK), which is the knowledge about the processes and practices or methods of teaching and learning, (c) pedagogical content knowledge (PCK), which is the intersection of PK and CK consistent with Shulman's PCK notion, (d) technological knowledge (TK), which is the knowledge about standard and more advanced technologies, and skills to operate particular technologies, (e) technological content knowledge (TCK), the intersection of TK and CK, which is knowledge about the manner in which technology and content are related, (f) technological pedagogical knowledge (TPK), the intersection of TK and PK, which is the knowledge of various technologies to be used in teaching and learning settings, and (g) technological pedagogical content knowledge (TPCK), the intersection among TK, CK and PK, which is an emergent form of knowledge beyond all other components (Mishra & Koehler, 2006). The researchers define the TPCK as:

> the basis of good teaching with technology and requires an understanding of the representation of concepts using technologies; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge and to develop new epistemologies or strengthen old ones. (Mishra & Koehler, 2006, p. 1029)

After the first conceptualization of TPCK with these leading definitive studies, the framework become widely popular and started to be adapted for different context. In 2007, the acronym of technological pedagogical content knowledge was proposed to be changed from TPCK to TPACK for increasing the fluency of pronunciation (Thompson & Mishra, 2007). This acronym was also selected to imply that the different domains of knowledge should not be considered in isolation rather they should be regarded as an integrated whole, a Total PACKage (Thompson & Mishra, 2007). In their later conceptualization of TPACK, Koehler and Mishra (2008) gave more emphasis on the role of context. They viewed the teaching with technology as "wicked problem" due to the complexities of the situations and contexts presented by learners and classrooms. While placing content, pedagogy and technology knowledge at the heart of good teaching with technology, they emphasized the differences of the relationships between and among these three components across diverse contexts.

Later adaptations of TPACK framework arose in need of addressing the complexities of specific context and the role of different variables in technology integration. Therefore, further attempts for theoretical conceptualization of TPACK were in search for more elaborated theoretical models to explain the role of these variables and to reflect the complexities of specific context. For this reason, Jimoyiannis (2010) proposed Technological Pedagogical Science Knowledge (TPASK) to reveal the complexities of technology integration into science teaching. Jimoyiannis (2010) designed a new integrated framework for science teachers' professional development by building on the TPACK framework and authentic learning approach. The researcher clarified the components of TPASK and the connections among science, pedagogy and technology in the context of secondary education settings. The researcher provided detailed explanation of pedagogical science knowledge (PSK), technological science knowledge (TSK) and TPK dimensions. According to the TPASK model, PSK includes seven knowledge components, namely, scientific knowledge, science curriculum, transformation of scientific knowledge, students' learning difficulties about specific scientific fields, learning strategies, general pedagogy, and educational context. For TSK, the researcher identified four knowledge components, namely, resources and tools available for science subjects, operation and technical skills related to specific scientific knowledge, transformation of scientific knowledge, and transformation of scientific processes. Under TPK dimensions, six knowledge components were defined, namely, affordances of ICT tools, learning strategies supported by ICT, fostering scientific inquiry with ICT, information skills, student scaffolding, students' technical difficulties. Based on these defined knowledge components, Jimoyiannis (2010) designed a TPASK coursework. The study was unique in the sense that provides a detailed explanation of TPACK dimensions for science teaching and a related curriculum to develop TPASK of teachers and pre-service teachers. Therefore, the provided explanations were considered in deciding the design requirements and constructing the initial design principles.

Concurrently, Lee and Tsai (2010) provided a framework for understanding teachers' Technological Pedagogical Content Knowledge-Web (TPCK-W). Lee and Tsai (2010) contextualized the technology knowledge of TPACK in World Wide Web context. Lee and Tsai (2010) developed TPCK-W in need of a more specific information to improve teacher preparation and professional development when integrating Web into instruction, since they argued that TPCK might not provide sufficient information due to the general discussion of technology in TPCK. According to the researchers, the use of Web for educational purposes provides many possibilities, and these affordances bring along new challenges for teachers in their pedagogical practice with the Web. Therefore, teachers should possess more nuanced knowledge than TPCK when teaching with the Web. For this purpose, they proposed TPCK-W framework by building upon Shulman's PCK and Mishra and Koehler's (2006) TPACK framework.

Similarly, Benton-Borghi (2013) proposed the Universally Designed for Learning (UDL) infused TPACK framework in need for a more encompassing framework to include the needs for every individual learners. Therefore, they proposed UDL-infused TPACK for guiding the practitioners to prepare teachers with the knowledge, skills, and dispositions needed to teach the full spectrum of learners. The researcher recommended merging two innovative frameworks, TPACK and UDL, to enable teachers to consider multimodal affordances of all technologies –including assistive technology- to improve performance outcomes of diverse and exceptional learners. The researcher claimed that "the synthesis of these two separate frameworks supports a 21st century understanding of teaching and student learning in a collaborative, inclusive, equitable, and less divided system of education" (Benton-Borghi, 2013, p.255). According to the researcher, infusion of UDL into TPACK framework is essential due to the insouciance of assistive technologies in general teacher education programs.

Similar to Benton-Borghi's (2013) elaboration of TPACK to reflect the complexity of context, Ling Koh, Chai, & Tay (2014) proposed TPACK-in-action to expand the context knowledge in the framework. They defined four contextual factors affecting teachers' design of ICT lessons, which are physical/technological, cultural/institutional, interpersonal and intrapersonal factors. Based on the first-order and second-order barriers to technology integration (Ertmer, 1999, 2005), the researchers termed the contextual variables that teacher should manage while designing ICT lessons. The physical/technological factors as a first order barrier to technology integration refers to issues related to availability of resources like hardware, software and technology support staff. Another first order barrier, cultural/ institutional factors refers to the institutional influences of society and culture, educational policies, school leadership, school policies, and curriculum on teachers' teaching practice. While the formers include the access to the resources, equipment, time or training, the second-order barriers are related to teachers' mental variables and affect the strength of first-order barriers. The intrapersonal factor was termed by Ertmer (1999) and Ling Koh et al. (2014) as a second-order barrier to technology integration and refers to teachers' various forms of beliefs. Another contextual variable affecting ICT integration was defined as inter-personal context and includes the issues related to problem-solving and innovation through collaborative design teams (Ling Koh et al., 2014). Besides these contextual variables, Ling Koh et al. (2014) argued that teachers' design capacities deserves deeper examination to determine the specific competencies to facilitate teachers' discourse about their design in ways that support pedagogical improvement.

TPACK framework serves as a "conceptual lens" about effective technology integration. However, providing well-defined framework is not enough, since frameworks have to be examined within the real settings through the instruments that are consistent with the theory (Koehler, Shin, & Mishra, 2012). In order to contribute to the theoretical basis of TPACK, survey studies were conducted. For this reason, reliable and valid measures were aimed to be developed to investigate (pre-service) teachers' TPACK. As the definition of TPACK framework, there is a lack of consensus on how to assess TPACK through reliable instruments (Shinas, Karchmer-Klein, Mouza, Yilmaz Ozden, & Glutting, 2015). Participants' TPACK were generally investigated through surveys developed from an integrative perspective (Baran & Canbazoğlu Bilici, 2015), except few studies in which surveys were developed from transformative perspective (Kabakci-Yurdakul et al., 2012). Although it may not cover the whole literature about instrument development, Table 3 provides a summary of instruments developed to measure TPACK.

Table 3
Summary of TPACK Instruments in the Literature

Authors	Sub-dimensions of the test	Participants	Contextualization			
			TK	PK	CK	None
Schmidth et al. (2009)	TK, CK (Social science, Mathematics, Science, Literacy), PK, PCK, TCK, TPK, TPACK	Pre-service teachers				✓
Archambault & Crippen (2009)	TK, CK, PK, PCK, TCK, TPK, TPACK	K-12 online distance educators	✓			
Graham et al. (2009)	TPACK, TPK, TCK, TK	In-service science teachers			✓	
Lee & Tsai (2010)	Web-General, Web-Communicative, Web-CK, Web-PCK, Attitude Toward Web-Based Instruction	Teachers from elementary school to high school	✓			
Şahin (2011)	TK, CK, PK, PCK, TCK, TPK, TPACK	Pre-service teachers				✓
Lux et al. (2011)	PK, TK, CK, PCK, TPK, TPACK	Pre-service teachers				✓
Chai et al. (2011)	TK, PKML, CK, TPK, TPACK	Pre-service teachers		✓		
Kabakci-Yurdakul et al. (2012)	Design, Exertion, Ethics, Proficiency	Pre-service teachers				✓
Jang & Tsai (2012)	CK, PCK in the Context (PCKCx), TK, TPACK in the Context (TPCKCx)	Elementary mathematics and science teachers	✓			
Zelkowski et al. (2013)	TPACK, TK, CK, PK	Secondary mathematics pre-service teachers			✓	
Canbazoğlu Bilici et al. (2013)	TK, CK, PK, PCK, TCK, TPK, TPACK, CxK	Pre-service teachers			✓	
Liang et al. (2013)	CK, PK, PCK, TK, TPTCK (Unified TPK and TCK), TPCK	In-service preschool teachers				✓
Jang & Chen (2013)	Subject Matter Knowledge (SMK), Instructional Representation & Strategies (IRS), Knowledge of Students' Understanding (KSU), Technology Integration and application (TIA)	College students majoring in biology, physics, chemistry, and engineering				✓

Table 3 (continued)

Summary of TPACK Instruments in the Literature

Authors	Sub-dimensions of the test	Participants	Contextualization			
			TK	PK	CK	None
Hsu et al. (2013)	Game Knowledge (GK), Game-PK (GPK), Game-PCK (GPCK)	In-service teachers	✓			
Shih & Chuang (2013)	Subject Matter Knowledge (SMK), TK, KSU, TPACK	Undergraduates from colleges				✓
Jamieson-Proctor et al. (2013)	TPK, TCK, TPACK	Pre-service teachers				✓
Sang et al. (2016)	TK, CK, PK, PCK, TCK, TPK, TKW, TPACK	Pre-service teachers				✓
Koh et al. (2014)	Constructivist (C)-TK, C-PK, CK, C-PCK, TCK, C-TPK, C-TPACK	Practicing teachers		✓		
Baser et al. (2015)	TK, CK, PK, PCK and Combination of TCK, TPK, and TPACK	Pre-service teachers of English as a foreign language			✓	
Tseng (2016)	TK, TPK, PCK, Combination of PK and CK, Mix of TCK and TPACK	English as a foreign language students			✓	

Schmidt et al. (2009) was the first to develop a scale to measure PSTs' TPACK perceptions. They developed an instrument based on Mishra and Koehler's (2006) conceptualization of TPACK. They aimed to develop a valid and reliable survey to provide educators a self-assessment instrument to examine pre-service teachers' TPACK development in their longitudinal studies. Although the sample size was small to perform a factor analysis on the entire instrument, and some of the sub-scales' item number was insufficient, the study was the initiator of further instrument development studies. Many studies translated and adapted Schmidt et al.'s (2009) instrument (e.g. Kaya & Dağ, 2013; Koh, Chai, & Tsai, 2010; Semiz & Ince, 2012). Keeping in mind Schmidt et al.'s (2009) advice on insufficiency of item numbers, Koh et al. (2010) extended the content-related factors (CK, PCK, TCK, TPACK) by adding items.

Since further TPACK frameworks emerged in need of obtaining more specific information about teachers' knowledge required for technology integration about specific technology, content or pedagogy, some of the further survey studies also attempted to contextualize TPACK survey in specific technology, pedagogy or content area. As it can be seen from the Table 3, there are some TPACK instruments for specific content area, a few studies for specific technology and only two studies for specific pedagogy. Archambault and Crippen (2009) developed an instrument to measure online distance education teachers' knowledge. They constructed items specific to figure out what online teachers should know and be able to do. Survey includes items such as "My ability to moderate online interactivity among students" in TPK and "My ability to meet the overall demands of online teaching" in TPACK domain. Similarly, Lee and Tsai (2010) developed an instrument to assess teachers' perceived self-efficacy in terms of web pedagogical content knowledge based upon the TPACK-Web framework including Web Knowledge, Web-Content Knowledge, Web-Pedagogical Knowledge and Web-Pedagogical-Content Knowledge. Sample items can be given for Web-communicative as "Be able to set a nickname by yourself in an online chatroom." for WCK as "Be able to search related online materials for course content." and for WPCK as "Be able to use Web technology to support teaching for the content of a particular course unit." The similarity of TPACK-Web with TPACK survey of Archambault and Crippen (2009) is that the factors related to technology-related PK and technology-related PCK unified in factor analysis as opposed to their hypothesized models.

Jang and Tsai (2012) developed instrument specific to another commonly used technology, interactive whiteboards (IWB). They found that elementary teachers who use IWB have significantly higher TPACK than the teacher who do not use. Critiquing the studies treating technology in a general manner, Hsu, Liang, Chai and Tsai (2013) developed an instrument to assess pre-school teachers' confidence in TPACK about computer games. The researchers also developed an instrument to examine pre-school teachers' acceptance of digital game-based learning. According to the path analysis results, the researchers cautioned practitioners about the importance of developing basic technological knowledge and then enhance TPK before attempting to develop TPCK in professional development trainings.

Similar to TPACK measures for specific technologies, there are some studies contextualizing TPACK in specific pedagogies as illustrated in Table 3. Moving beyond the validation studies of seven-factor construct of TPACK, Chai, Koh, Tsai and Tan (2011) examined the construct validity of a TPACK survey that was contextualized for pedagogical approaches employed in a designed ICT course. They adapted the TPACK survey of Schmidt et al. (2009) by making changes in the items according to the study context and removing the PK dimension of the survey. Instead, Chai et al. (2011) added 13 items created to measure five dimensions of meaningful learning and labelled PK dimensions as Pedagogical Knowledge for Meaningful Learning (PKML). An example to PKML item can be given as "I know how to guide my student to learn independently". The researchers constructed pre and post-course structural equation models to explain the relationships among the five of the seven TPACK constructs that were yielded better model fit in the study and made conclusions about the knowledge development pathways of the teachers. Chai et al. (2011) suggested further studies to construct highly contextualize TPACK surveys to understand the issues in their own teacher education context better.

Koh, Chai, and Tsai's (2014) constructivist-oriented TPACK survey is another example to pedagogy-specific TPACK surveys. The researchers adapted Chai et al.'s (2011) TPACK for meaningful learning survey. They operationalized TPACK for constructivist learning in items as "I can formulate in-depth discussion topics about the content knowledge and facilitate students' online collaboration with appropriate tools (e.g., Google Sites, CoveritLive)". Contrary to Chai et al. (2011), Koh et al. (2014) confirmed the hypothesized seven-factor structure of the survey through the confirmatory factor analysis with satisfactory model fits. According to the regression results, the researchers reached a conclusion that Constructivist-TPK has the strongest power in explaining constructivist-TPACK, so that it should be developed by increasing teachers' knowledge of ICT tools that support constructivism.

There are relatively more studies constructing content-specific TPACK surveys in the literature. Graham, Burgoyne, Cantrell, Smith, St. Clair, and Harris (2009) and Canbazoğlu Bilici et al. (2013) developed content-specific TPACK surveys for science. While Graham et al. (2009) developed four-factor TPACK survey with only technology-related factors; Canbazoğlu Bilici et al. (2013) developed eight-factor survey including seven TPACK factors and one additional contextual knowledge factor. Similarly, Zelkowksi, Gleason, Cox, and Bismarck developed an instrument specific to mathematics and Baser, Kopcha, and Ozden (2015) and Tseng (2016) developed instruments for English language teaching.

Content knowledge is vital for maximizing the effectiveness of technology integration, because selecting appropriate technologies for teaching content requires content-based PK and TK (Harris et al., 2009). Graham et al. (2009) utilized their TPACK in Science survey to figure out science teachers' TPACK and found that teachers felt themselves least confident in TCK. They declared that teachers generally used technology for general pedagogical strategies without considering content-specific technologies. Moreover, Young, Young and Shaker (2012) conducted a meta-analysis study to describe PSTs' TPACK using confidence interval as a means to examine TPACK survey studies and found that TCK was the least precise construct in terms of measurement. This finding showed the difficulty of measuring TCK construct across different content-specific contexts these studies even underscore the need for content-specific TPACK surveys to contribute to the framework better (Chai, Koh, & Tsai, 2016). Furthermore, the rapid development of technology and the availability of those emerging technologies (e.g. Google Earth for teaching geography) in content representations also necessitate the revisions of available surveys or development of new ones in specific content areas (Chai et al., 2016).

Contrary to the studies mentioned above, which are aiming to evaluate pre-service or in-service teachers' perceptions, competency or self-efficacy about their own TPACK, some of the studies targeted to measure perceptions of PSTs' about TPACK of others. Tseng (2016) conducted a study to validate a TPACK assessment tool that can be used to investigate English as Foreign Language (EFL) students' perceptions of their teachers' TPACK. The researcher pointed out the importance of PSTs' views about and reactions to their teachers' TPACK as a contributor to their own TPACK development.

The common problem faced in most of the development and validation of TPACK survey studies is about the factor structure of the instruments. Factor analysis of different instrument development studies yielded varying numbers of knowledge domains (Archambault & Barnett, 2010; Baser et al., 2015; Koh et al., 2010; Reyes, Reading, Rizk, Gregory, & Doyle, 2016). Especially, the knowledge domains at the center (i.e. TPK, TCK, and TPACK) are unified in one factor (Baser et al., 2015; Tseng, 2016). Voogt et al. (2013) supported the view that TPACK should be considered as a different body of knowledge. This brings the discussion about the epistemology of TPACK that is centered on whether it is transformative or integrative. All of the instruments discussed above were constructed based on integrative point of view that they assume the contribution of each knowledge domains on the TPACK and the results of these validation studies indicated the importance of approaching TPACK from transformative perspective.

On the other hand, there are also some frameworks conceptualizing teacher knowledge for technology integration form transformative point of view. From this perspective, Angeli and Valanides (2005) was first to define the teacher knowledge required for effective technology integration as ICT-related PCK. They defined the ICT-related PCK as a special amalgam of pedagogical knowledge, subject area knowledge, knowledge of students, knowledge of environmental context, and ICT knowledge. For them, the teachers who have ICT-related PCK are competent to teach with ICT, and can synthesize their knowledge about tools, and their affordances, pedagogy, content, learners, and context for developing an understanding about how they can teach a particular topic to specific learners with ICT in specific context in ways that signify the added value of ICT (Angeli & Valanides, 2005, 2009). Moreover, Angeli and Valanides (2005) defined the principles of ICT-related TPACK to be guide in designing ICT-enhanced learning. These principles are as follows:

> 1. Identify topics to be taught with ICT in ways that signify the added value of ICT tools, such as topics that students cannot easily comprehend, or teachers face difficulties in teaching them effectively in class.
> 2. Identify representations for transforming the content to be taught into forms that are comprehensible to learners and difficult to be supported by traditional means.
> 3. Identify teaching strategies, which are difficult or impossible to be implemented by traditional means, such as application of ideas into contexts not possible to be experienced in real life, interactive learning, dynamic and context-situated feedback, authentic learning, and adaptive learning to meet the needs of any learner.
> 4. Select ICT tools with inherent features to afford content transformations and support teaching strategies.
> 5. Infuse ICT activities in the classroom. (p. 294)

At the same time, Niess (2005) recognized the important role of technology not only in curriculum but also in the instruction. The researcher proposed a teacher education program to overcome the challenge of preparing teachers to teach from an integrated knowledge of subject matter, pedagogy and technology. She claimed that to do so "preservice teachers must also develop an overarching conception of their subject matter with respect to technology and what it means to teach with technology—a technology PCK (TPCK)" (Niess, 2005, p.510). Niess (2005) adapted the four components of Grossman's (1990) PCK to describe technology-enhanced PCK. By integrating the technology knowledge into PCK components, the researcher provided a theoretical framework to explain the outcomes for TPCK development in a teacher education program. These TPCK components are named as (a) an overarching conception of what it means to teach a particular subject integrating technology in the learning; (b) knowledge of instructional strategies and representations for teaching particular topics with technology; (c) knowledge of students' understandings, thinking, and learning with technology in a particular subject; (4) knowledge of curriculum and curriculum materials that integrate technology with learning in the subject area. Since the framework proposed by Niess (2005) showed to be helpful in further studies to explain the outcomes of teacher education programs in terms of TPACK development, it was decided to be utilized in this dissertation to evaluate the outcomes of the re-designed course in terms of TPACK development of PSTs in the context of SSI teaching.

In 2009, Niess, Ronau, Shafer, Driskell, Harper, Johnston, Browning, Özgün-Koca, and Kersaint explained what knowledge is needed to teach mathematics with digital technologies in detail. They defined the mathematics teachers' TPACK standards. The researchers proposed mathematics teacher TPACK standards and indicators under four main themes, namely, designing and developing digital-age learning environments and experiences; teaching, learning and the mathematics curriculum; assessment and evaluation; productivity and professional practice. Firstly, teachers should be able to design and develop authentic learning environments and experiences incorporating appropriate digital-age tools and resources to maximize mathematical learning in context. Moreover, teachers should be able to implement curriculum plans that include methods and strategies for applying appropriate technologies to maximize student learning and creativity in mathematics. Then, teachers should be able to apply technology to facilitate a variety of effective assessment and evaluation strategies. Lastly, teachers should be able to use technology to enhance their productivity and professional practice. The details about the indicators of the standards can be read from Niess et al. (2009). Besides defining the standards, the researchers proposed a TPACK development model with a detailed explanation of themes, levels and descriptors of TPACK development.

Contrary to the above transformative frameworks that emerged in need of developing effective teacher education programs, Yeh et al. (2014) proposed the TPACK-Practical framework to explain experienced teachers' TPACK components. TPACK-Practical includes eight knowledge dimensions, namely, using ICT to understand students, using ICT to understand content, planning ICT-infused curriculum, using ICT representations, using ICT-integrated teaching strategies, applying ICT to instructional management, infusing ICT into teaching contexts, and using ICT to assess students, under five pedagogical areas (i.e. subject matter, learners, curriculum design, assessments, and practical teaching). They validated the framework with 54 experts who are science-related educators through Delphi survey method. The indicators of TPACK-Practical make TPACK more practically oriented in actual instructional contexts. They argued that due to the dynamic nature of teachers' knowledge and major influence of teacher experience on PCK, experienced teachers' TPACK is different from pre-service teachers and should be defined accordingly (Hsu, Yeh, & Wu, 2015). Therefore, their framework was intended to be a working model of TPACK within an actual teaching context such as science. Since in this dissertation, the participants were pre-service science teachers who did not have any experience about SSI teaching, this framework was considered as not much helpful in designing and assessing an undergraduate course with a purpose of TPACK development about SSI teaching.

Similar to TPACK-Practical, another TPACK framework was proposed by Porras-Hernández and Salinas-Amescua (2013) to elaborate the contextual knowledge for teaching in actual settings. The researchers tried to strengthen an already existed TPACK framework proposed by Angeli and Valanides (2005) by including a broader notion of context to reflect the complexity of context knowledge. Porras-Hernández and Salinas-Amescua (2013) argued that in previous TPACK frameworks, context knowledge was used in different and multiple meanings some of which are "(a) the students characteristics; (b) classroom and institutional conditions for learning: (c) situated teaching activities; and (d) the teacher's epistemological beliefs" (p.226). Therefore, the researchers proposed two dimensions of context, namely, scope (i.e. macro, meso, and micro level context) and actor (i.e. students' and teachers' context) to initiate the discussion about the complexity of context knowledge more systematically to build an agreement and reach a better understanding of teacher knowledge. They defined three levels of context that affect teachers' practice and that are the objects of knowledge to be considered by teachers. The researchers defined the most general level, macro context as social, political and economic conditions including the worldwide technological developments necessitating the constant learning of teachers. The social, cultural, political, organizational and economic conditions of the local community and the educational institutions were termed as meso context level. Finally, the in-class conditions for learning like available resources, norms and policies, expectations, beliefs, preferences, and goals of actors was termed as micro level context.

While detailing the actors' context, Porras-Hernández and Salinas-Amescua (2013) emphasized the importance of learners' inner characteristics and external conditions of the learners. In a similar vein, the teacher as the other important actor is also an object of knowledge. Although the whole framework represents the teacher knowledge, their self-efficacy, pedagogical beliefs, subject or school culture, familiarity with technology, their expectancies and values, and attitudes toward technology are also important variables affecting their technology integration. Therefore, the researcher suggested to include the knowledge of students and teacher' self-knowledge across the different levels of context. Although this framework was helpful in determining and developing TPACK of in-service teachers, it might not be illuminative in terms of TPACK development of pre-service teachers. Therefore, it was not utilized in this study. However, the emphasis of the framework on the role of teachers' self-knowledge on their TPACK was appreciated. Therefore, PSTs' TPACK was decided to be investigated by activating their metacognition. By this way, PSTs were urged to think about their self-knowledge in planning and implementing technology-integrated SSI lessons.

As it can be summarized from the studies defining the teacher knowledge required for technology integration, after the initial definitions of TPACK, further attempts of developing TPACK framework arose from the need for more specific and situated knowledge. The frameworks explained above situated the TPACK of teacher in either specific content area or specific technology. Moreover, it was claimed that while putting TPACK into action, teachers face with the boundaries of the context. Therefore, a great deal of effort was spent for elaborating and defining the context knowledge surrounding the TPACK. It was also claimed that TPACK could not be thought as such static knowledge dimensions as due to its evolving nature all the time. Overall, it can be said that TPACK is a situated and dynamic knowledge.

2.1.2.1. TPACK framework of this dissertation

Among all the TPACK frameworks, Niess's (2005) TPACK framework was decided to utilize in this dissertation for two reasons. Firstly, as it was articulated in the first chapter of the dissertation, there are two epistemological stances about teacher knowledge and TPACK. The current review studies indicate that TPACK is a transformative knowledge and teacher education programs should attempt to develop teachers TPACK from a transformative perspective (Angeli et al., 2016). However, there are not much transformative TPACK frameworks mentioned in the literature except few relatively recent studies (Kabakci-Yurdakul et al., 2012; Yeh et al., 2014).

Among these frameworks, Niess's (2005) definition for the components of TPACK was best suited to our goal that is developing effective SSI teaching practices with technology. Angeli and Valanides (2005; 2009) also proposed a theoretical framework for developing TPACK-ICT; however, their principles were limited to instructional design and do not give detailed information about enactment of the designs. Niess' (2005) framework was more suitable to design courses and analyze data including the instructional design and enactment of their design. However, Niess's (2005) have limitation in differentiating the knowledge about assessment. Niess (2005) utilized the central components of PCK defined by Grossman (1990) to view preservice teachers' development of TPACK. Magnusson, Krajcik and Borko (1999) built upon the work of Grossman (1990) to define the pedagogical content knowledge specific to science teachers. In their model, Magnusson et al. (1999) conceptualize PCK with five components including "(a) orientations toward science teaching, (b) knowledge and beliefs about science curriculum, (c) knowledge and beliefs about students' understanding of specific science topics, (d) knowledge and beliefs about assessment in science, and (e) knowledge and beliefs about instructional strategies for teaching science" (p.97) (Figure 3).

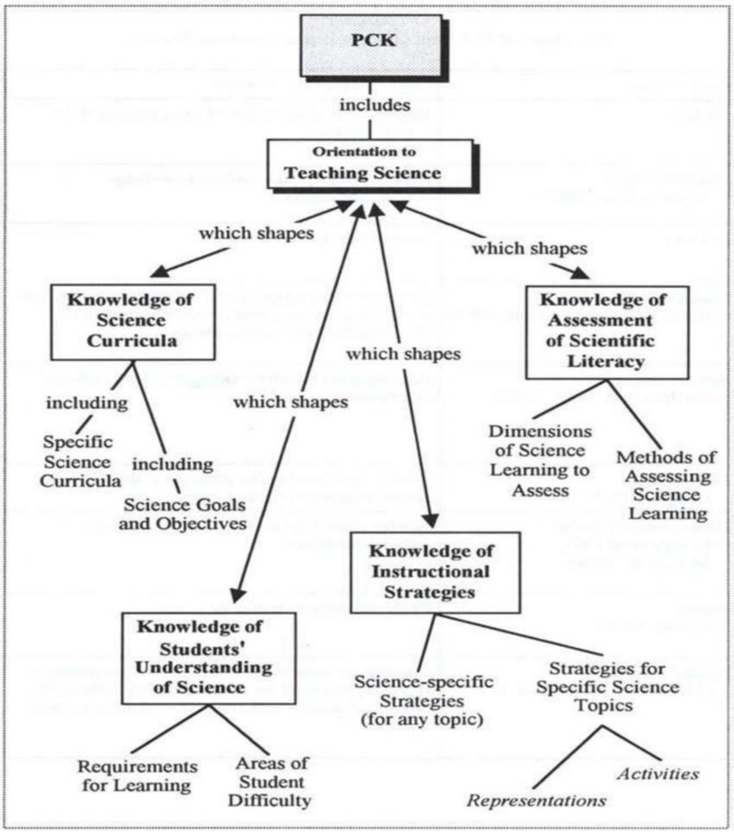

Figure 3. Components of pedagogical content knowledge framework (Magnusson et al., 1999, p.99)

Therefore, building on PCK framework of Magnusson et al. (1999), it was decided to add a new component to Niess's (2005) TPACK framework about assessment. In addition to the four components of TPACK explained in the introduction, fifth component was defined as knowledge and beliefs about assessment with technology for effective SSI teaching. Each of the sub-dimensions of TPACK for this study was conceptualized as explained below.

1. An overarching conception about the purposes for incorporating technology in effective SSI teaching

This component was positioned at the top of the four components of PCK as illustrated in Magnusson et al.'s (1999) PCK model, because it was argued that teachers' beliefs or conceptions about science teaching have influence on other components of science teaching PCK. In a similar vein, this component is argued to serve as a basis for all instructional decisions about technology integration (Niess, 2012). Therefore, in the context of TPACK, this component was operationalized as PSTs' beliefs about general purpose of using technology in science teaching (using technology to facilitate inquiry-based science learning or using technology to deliver scientific knowledge to students etc.), about the role of teacher and student in technology-integrated science lessons.

2. Knowledge of instructional strategies and representations for effective SSI teaching with technologies

Knowledge of instructional strategies component of PCK include both subject-specific strategies that are broader like strategies specific to science teaching and topic-specific strategies that can be applied particular topics in science (Magnusson et al., 1999). In TPACK framework, this component refers to teachers' knowledge in guiding students learning subject matter topics with technologies and in employing content-specific representations with technologies to reach the goals of the instruction (Niess, 2012). Therefore, in this study, this component refers to the knowledge of instructional strategies that are suitable for teaching SSI topics effectively. Moreover, their knowledge of technological representations used while implementing those instructional strategies was aimed to be figured out under this component.

3. Knowledge of students' understandings, thinking, and learning in SSI topics with technology

Magnusson et al. (1999) defined this component in PCK framework as "the knowledge teachers must have about students in order to help them develop specific scientific knowledge." (p. 104). They mentioned two categories of this kind of knowledge including knowledge of requirements for learning and knowledge of areas of student difficulty. According to Niess (2012) "teachers rely on and operate from their knowledge and beliefs about student' understandings, thinking, and learning with technologies in specific subject matter topics." (p. 5). Therefore, under this component, PSTs' knowledge about their student' prior knowledge required to be engaged in SSI reasoning as well as the possible misconceptions or learning difficulties that may interfere with their reasoning was considered. Moreover, since students' cognitive and moral developmental level was important for their scientific and moral reasoning, PSTs' knowledge about their students' developmental level was also considered under this component. Besides, PSTs' knowledge about the strategies to elicit and deal with students' prior knowledge and misconceptions with the help of technology was also included under this component.

4. Knowledge of curriculum and curricular materials that integrate technology in effective SSI teaching

According to Magnusson et al. (1999), knowledge of science curriculum includes two categories, which are knowledge of goals and objectives and knowledge of specific curricular program. Specifically, Magnusson et al. (1999) argued that "Teachers' knowledge of curricula … would include knowledge of the general learning goals of the curriculum as well as the activities and materials to be used in meeting those goals." (p. 104). Similarly, Niess (2012) defined this component as "With respect to the curriculum, teachers discuss and implement various technologies for teaching specific topics and how subject matter concepts and processes within the context of a technology-enhanced environment are organized, structured, and assessed throughout the curriculum." (p.5). Therefore, PSTs' knowledge about curriculum goals and specific objectives regarding each learning area defined in the curriculum was considered in this dimension.

5. Knowledge of assessment with technology in effective SSI teaching

This component was not included in Niess's (2005) TPACK framework. However, it was deemed worthy of treating it as a different component of teachers' technology integration knowledge. Magnusson et al. (1999) defined science teachers' assessment knowledge as "knowledge of the dimensions of science learning that are important to assess, and knowledge of the methods by which that learning can be assessed" (p. 108). Extending to TPACK framework, this component was conceptualized as knowledge of dimensions of SSI learning with technology that are important to assess and knowledge of methods and technological tools by which learning can be assessed.

2.1.3. Metacognition

As it was mentioned in the knowledge required for technology integration, whether they were based on integrative perspective or transformative perspective, TPACK frameworks evolved in need of elaborating the context. In Porras-Hernández and Salinas-Amescua's (2013) transformative TPACK framework, the teachers' characteristics were also defined as one of the contextual factors. They emphasized the importance of teachers' self-knowledge in technology integration and suggested considering teachers' self-efficacy, pedagogical beliefs, familiarity with technology, their expectancies and values, and attitudes toward technology.

Shulman (1986) emphasized the role of metacognition and reflection on teacher knowledge as:

> The teacher is capable of reflection leading to self-knowledge, the metacognitive awareness that distinguishes draftsman from architect, bookkeeper from auditor. A professional is capable not only of practicing and understanding his or her craft, but of communicating the reasons for professional decisions and actions to others. (p13)

This highlighted the importance of teacher metacognition in technology integration. Therefore, in order to define teacher metacognition, firstly, definitions of metacognition were sought in the literature.

Metacognition can simply be thought as cognition of cognition or thinking about thinking (Jacob & Paris, 1987; Schraw, Crippen, & Hartley, 2006). Following the influential work of Flavell (1979) and Brown (1978), many studies have been conducted about metacognition. However, operational definition of it is not clear in the literature. According to Flavell's (1979) definition, metacognition is "one's knowledge concerning one's own cognitive processes and products or anything related to them" (p. 232). As from the introduction of metacognition term (Flavell, 1979), metacognitive knowledge and metacognitive skills were often described separately. The former represents one's declarative knowledge about person, task and strategy characteristics, while the latter pertains to acquired ability of monitoring, guiding, steering, and controlling one's learning and problem-solving behavior (Veenman, 2011). "Metacognitive beliefs, metacognitive awareness, metacognitive experiences, metacognitive knowledge, feeling of knowing, judgment of learning, theory of mind, metamemory, metacognitive skills, executive skills, higher-order skills, metacomponents, comprehension monitoring, learning strategies, heuristic strategies, and self-regulation" (Veenman, Van Hout-Wolters, & Afflerbach, 2006, p. 4) are all stated to be related to metacognition concepts. There is not a commonly accepted definition of metacognition and its components. Table 4 includes a brief summary of the component and definitions of the components according to some pioneering theorists.

From the first appearing of metacognition term (Flavell, 1979), two major components of it was defined by using different terminologies. Generally these two terms denotes the 'knowledge of cognition' and 'regulation of cognition'. The first one is relatively stable, statable and fallible in nature, while the latter includes unstable activities that are often not statable (Brown, 1987). Commonly, these two components reflect the knowledge base and process base of metacognition. In Flavell's (1979) description of metacognition, these two components were defined as metacognitive knowledge and metacognitive experiences.

Metacognitive knowledge is defined as "knowledge or beliefs about what factors or variables act and interact in what ways to affect the course and outcome of cognitive enterprises" (Flavell, 1979, p. 907) and these factors were categorized as person, task and strategy. The person category includes the intraindividual differences as well as interindividual differences and universals of cognition. It is the belief about the self in general and other people as cognitive processors. The task category deals with the judgments about the tasks' goals and demands. The strategy category includes the knowledge about the strategies that are useful to reach specific goals and the strategies necessary for specific cognitive tasks.

Metacognitive experience of Flavell (1979) stated to be different from metacognitive knowledge in terms of function and content. These experiences include experiences that someone consciously is aware of and "occur in situations that stimulate a lot of careful, highly conscious thinking" (p. 908) like new tasks that are novel and require robust planning. These experiences help someone to revise the existing goals or establish new ones by also cause in modification in metacognitive knowledge base and activate cognitive or metacognitive goals.

Table 4
Summary of Pioneering Metacognitive Theories

	Theorists	Categories	Definitions
Knowledge of cognition	Flavell, 1979	Person	Everything that one believes about the nature of self and other people as cognitive processors.
		Task	Knowledge about the tasks' goals and demands
		Strategy	Knowledge about the strategies that are useful to reach specific goals and necessary for specific cognitive tasks
	Schraw & Moshman, 1995	Declarative knowledge	Knowledge about oneself as a learner and about what factors influence one's performance
		Procedural knowledge	Knowledge about the execution of procedural skills
		Conditional knowledge	Declarative knowledge about the relative utility of cognitive procedures
	Paris & Winograd, 1990	Self-appraisal	Personal reflections about one's knowledge states and abilities
	Pintrich, 2002	Strategic knowledge	Knowledge of general strategies for learning, thinking, and problem solving
		Knowledge of cognitive task	Knowledge of tasks and contexts and how they can influence cognition
		Self-knowledge	Knowledge of one's strengths and weaknesses
Regulation of cognition	Flavell, 1979	Metacognitive experience	Experiences occur in situations that stimulate a lot of careful, highly conscious thinking
	Schraw & Moshman, 1995	Planning	Selection of appropriate strategies and the allocation of resources that affect performance
		Monitoring	One's on-line awareness of comprehension and task performance
		Evaluating	Appraising the products and regulatory processes of one's learning
	Paris & Winograd, 1990	Self-management	Metacognitions in action, or how metacognition can orchestrate cognitive aspects of problem solving.
	Pintrich et al., 2000	Metacognitive judgments and monitoring	General metacognitive processes including (a) task difficulty or ease of learning judgments (b) learning and comprehension monitoring or judgments of learning, (c) feeling of knowing and (d) confidence judgments
		Self-regulation and control	Activities that individuals engage in to adapt and change their cognition or behavior

Other categorization of metacognition was proposed by Schraw and Moshman (1995). They defined two components of metacognition as knowledge of cognition and regulation of cognition. Similar to Flavell's (1979) metacognitive knowledge of person, Schraw and Moshman (1995) defined the knowledge of cognitions as "what individuals know about their own cognition or about cognition in general" (p. 352). According to their conceptualization of metacognition, metacognitive knowledge includes the declarative, procedural and conditional knowledge about cognition (Schraw & Dennison, 1994; Schraw & Moshman, 1995). Declarative knowledge of Schraw and Moshman (1995) includes the knowledge about self as a learner and the factors influencing owns performance. Procedural knowledge is the knowledge about the procedural skills, while conditional knowledge includes the knowledge about when and why to apply different cognitive actions. Conditional knowledge can also be termed as "declarative knowledge about the relative utility of cognitive procedures" (Schraw & Moshman, 1995, p. 353). Regulation of cognition was defined as the activities helping control one's thinking or learning by Schraw and Moshman (1995) and three essential skills was reported as planning, monitoring and evaluation (Paris & Winograd, 1990; Schraw & Moshman, 1995; Schraw et al., 2006; Whitebread et al., 2009).

In their study aiming to construct an inventory to measure adults' metacognitive awareness, Schraw and Dennison (1994) operationalized regulation of cognition with five construct with additional constructs of information management strategies and debugging strategies. Schraw and Dennison (1994) defined the information management as "skills and strategy sequences used on-line to process information more efficiently (e.g., organizing, elaborating, summarizing, selective focusing)" (pp. 474-475) and the debugging as "strategies used to correct comprehension and performance errors" (p. 475).

Paris and Winograd's (1990) categorization of metacognition differs from other metacognitive theories. The researchers proposed self-appraisal and self-management as two essential features of metacognition. They defined self-appraisal as "personal reflections about one's knowledge states and abilities" (p. 8) and stated that these appraisals reflect static judgments based about the ability in hypothetical situations. On the contrary, self-management was declared as metacognition in action. According to Paris and Winograd (1990) self-management deals with how metacognition can organize cognition about problem solving. Similar to Schraw and Moshman's (1995) categorization about regulation of cognition, Paris and Winograd (1990) proposed that self-management may occur before starting to task as planning, during the task for instant adjustments and after the task to revise it.

Contrary to other categorization, Pintrich, Walter and Baxter (2000) categorized metacognition into three which are (a) metacognitive knowledge (b) metacognitive judgments and monitoring, and (c) self-regulation and control of regulation. Pintrich's (2002) categorization of metacognitive knowledge includes strategic knowledge, knowledge about cognitive tasks and self-knowledge similar to Flavell's (1979) categorization. According to Pintrich (2002) strategic knowledge includes the knowledge about general learning, thinking and problem solving strategies. These strategies are applicable to any academic discipline or task rather than being specific to particular content. Knowledge of cognitive task implies the "what" and "how" of different learning and thinking strategies as well as "when" and "why" of using these strategies. Self-knowledge includes the knowledge related to one's strengths and weaknesses (Pintrich, 2002). Besides, students have knowledge about their capability to perform a task, goals about task and the interest and value of the task for them.

Although metacognitive knowledge was stated to be static in nature, metacognitive judgments and monitoring include more online and process-related activities (Pintrich et al., 2002). The metacognitive activities about metacognitive judgments and monitoring were categorized into four categories: "(a) task difficulty or ease of learning judgments (EOL), (b) learning and comprehension monitoring or judgments of learning (JOL), (c) feeling of knowing (FOK), and (d) confidence judgments" (Pintrich et al, 200, p.48). Self-regulation and control category was defined as the activities through which someone adapts and changes their cognition.

Although it is defined differently in different frameworks, there is a duality in the nature of metacognition that it suggests both the capability of stating knowledge about cognition and regulating that knowledge. Trying to use a 'blanket' terminology to express this duality is believed to cause the confusion in the literature about the definition of metacognition (Georghiades, 2004). On the other hand, these two components of metacognition are not two distinct constructs, but in close relationship with each other (Schraw & Dennison, 1994) that they cannot be taught in isolation. Metacognitive experiences may result in addition, deletion or revision in metacognitive knowledge (Flavell, 1979). Therefore, metacognition and the components of it are vital for any cognitive endeavor. Since teachers are engaged in problem solving for teaching, technology integration in teaching in particular, we assumed that teacher metacognition was worthy to investigate to investigate PSTs' metacognition about teaching SSI with technology. In order to understand the characteristics of teacher metacognition in particular, studies elaborating the abovementioned metacognition definitions to define teacher metacognition were reviewed.

2.1.3.1. Teacher metacognition

Metacognition is largely studied in relation to students' learning and academic performance. The relationship between metacognition and learning is highlighted in many research studies (Efklides, 2008; McCormick, 2003; Paris & Winograd, 1990; Pressley & Harris, 2006). As Pintrich (2002) pointed out metacognitive knowledge can be determinant of how students learn and perform in the classroom, because student with a detailed repertoire of strategies will be likely to use them to reach their goals. Likewise, having a metacognitive knowledge of a variety of strategies seems to apply what they learned in one setting to another one (Bransford, Brown, & Cocking, 1999). Moreover, the positive effect of metacognition on reasoning (Mevarech & Kramarski, 2003), problem solving skills (Kramarski, Mevarech, & Arami, 2002), scientific inquiry skills (Zion, Michalsky, & Mevarech, 2005), and retention of learning (Yuruk, Beeth, & Andersen, 2009) was identified in the literature. In all these studies, metacognition refers to learners' awareness, judgments and beliefs about their cognition.

Returning to the definition of Flavell (1979), metacognition is knowledge and regulation of any cognitive endeavor and teaching can also be regarded as a cognitive process (Yerdelen-Damar, Özdemir, & Ünal, 2015). However, research on teacher metacognition is different from conventional uses of metacognition. Although studies about metacognition concern about one's individual thoughts, teachers need different kind of metacognition, because teaching requires thinking about their own thoughts as well as adapting the environment in response to wide range of classroom variability (Lin, Schwartz, & Hatano, 2005). Teaching has challenges caused from different contextual variables and one solution or metacognitive strategy cannot be generalized to all situations as opposed to the strategies generally used for problem solving.

The distinction between students' and teachers' cognitional and metacognitional knowledge for classroom teaching and learning was articulated in Peterson's (1988) study by providing exemplifying cases. Peterson (1988) defined the metacognitional knowledge for classroom teaching as "the teacher's self-awareness and ability to reflect upon the cognitional knowledge that he or she has, both general and content-specific" (p. 7) and differentiate it from cognitional knowledge for classroom teaching by defining the latter as "knowledge of the mental processes or facilities by which learners acquire knowledge through classroom teaching" (p. 7).

McAlpine, Weston, Beauchamp, Wiseman and Beauchamp (1999) argued that metacognition construct provides a good theoretical basis to explain and define thinking about one's practice and to operationalize the term 'reflection'. Therefore, some studies attempted to use metacognition construct to explain thoughtful actions of teachers or pre-service teachers (Artz & Armour-Thomas, 1998; Hartman, 2001; Lin et al., 2005; Yerdelen-Damar et al., 2015). These researchers operationalized teacher metacognition differently.

Hartman (2001) divided teacher metacognition into two as teaching with metacognition and teaching for metacognition, and defined the former as:

> It includes reflecting on: instructional goals, students' characteristics and needs, content level and sequence, teaching strategies, materials, and other issues related to curriculum, instruction and assessment. Such thinking occurs before, during and after lessons in order to maximize instructional effectiveness. (p. 149)

According to Hartman (2001), teaching for metacognition includes the thinking of teachers about how their instruction can enhance students' metacognition, or about their own thinking as learners. The literature about teacher metacognition can also be divided into two according to this duality. In the scope of this study, only teaching *with* metacognition was emphasized in the context of solving problem of technology integration into SSI teaching. Therefore, studies focusing only teaching with metacognition were included in the literature review.

Hartman (2001) defined two general types of the metacognition. One type of metacognition was defined as executive management strategies serving to plan, monitor and evaluate one's thinking processes and product. Other type was defined as strategic knowledge, which includes what information, skills or strategies one has, when and why to use them as well as how to use them. The researcher made operational definitions of these construct in the context of teaching. According to Hartman (2001) executive management metacognition in teaching is about "what and how you are going to teach, checking up on or monitoring how the lesson is going as you are teaching, making adjustments as needed, and evaluating how a lesson went after it is finished" (p. 150). The researcher also emphasized the importance of having a sound strategic knowledge to prepare a lesson effectively or making revisions during and after instruction when there is a need to select alternative approach. Hartman (2001) operationalized strategic metacognitive knowledge in teaching as "knowing what instructional strategies are in your repertoire, what they entail (declarative knowledge), when and why to use them (conditional knowledge), and how to apply them (procedural knowledge)" (p. 150).

The researcher recommended ways to help preservice teachers to teach metacognitively. Hartman (2001) first modeled teaching metacognitively by always thinking aloud so that pre-service teachers observed her. Then, she engaged pre-service teachers in a project in which they develop strategic metacognitive knowledge about a selected teaching strategy and prepare and enact a lesson plan through this strategy. She claimed that strategic metacognitive knowledge of teachers about instructional strategies can be elicited by the questions like "What is cooperative learning?"(p. 161) for declarative knowledge component. She suggested to use similar questions including ‘When’ or ‘Why’ questions for contextual or conditional knowledge and ‘How’ questions for procedural knowledge. However, these types of questions do not yield productive data in terms of making distinction between cognitional and metacognitional knowledge of teachers as it was articulated in Peterson’s (1988) study.

More recently, Yerdelen-Damar et al. (2015) provided a theoretical perspective about metacognition focusing on the knowledge base of metacognition. They preferred to use Flavell’s (1979) categorization of metacognitive knowledge to define pre-service teachers’ metacognitive knowledge and made operational definitions of person, strategy and task variables for teaching as a cognitive task. The researcher defined three sub-dimensions for person variable, which are metacognitive content knowledge (MCK), metacognitive method knowledge (MMK), and metacognitive knowledge about students’ knowledge (MSK). According to Yerdelen-Damar et al.’s (2015) definitions, MCK and MMK refer to one’s awareness about her/his knowledge on a specific content and a specific instructional strategy, respectively. MSK sub-dimension refers to preservice teachers’ metacognitive knowledge about students’ pre-instructional knowledge and reasoning. While strategy variable was conceptualized as teachers’ knowledge about instructional strategies they have, task variable refers to how pre-service teachers conceptualize their task of teaching. In their study, Yerdelen-Damar et al. (2015) compared pre-service teachers’ and researchers’ judgments about pre-service teachers’ knowledge related to the defined variables.

Lin et al. (2005) argued that metacognition in teaching serves to find problems, to set adaptive goals, to build identity and to clarify value, contrary to contextual features of traditional metacognition trainings that include well-defined problems, stable learning environments and shared values and goals. Therefore, they emphasized the need for alternative approaches to teacher metacognition and proposed Critical Event Instruction approach. In this approach researchers gave students teachers some events to be solved like having students with bad attitude toward science. The researchers developed a critical event based learning environment with multiple video vignettes illustrating the classroom challenges included in it. The unique property of this environment was asking teacher what additional information they need, providing multiple perspectives and encouraging reflecting on these perspectives. By asking these kinds of prompts to teachers, it was aimed to help them clarify the potential goals as the first step of adaptive metacognition. The computer-mediated instruction was found effective to help teachers' metacognition by encouraging teachers to make decisions about critical events and providing them opportunity to develop a habit of mind for seeking additional sources of information. This habit of mind was proposed to be effective especially in complex teaching situations. Therefore, the researchers claimed that activating teachers to deal with educational problems by considering all possible conditions and to seek for additional information to reflect on was important for adaptive metacognition of teachers.

Although teacher metacognition was not studied extensively, there are research studies showing the importance of metacognition of teachers. It is argued that teachers can increase the quality of their teaching by supporting their instruction with metacognition (Hartman, 2001; Yerdelen-Damar et al., 2015). Zohar (1999) focused on teachers' declarative metacognitive knowledge in relation to teaching thinking skills. She claimed that having general pedagogical knowledge and procedural knowledge about thinking skills is not enough to teach higher order thinking skills in an extensive and systematic way. To do so, teachers should have declarative metacognitive knowledge, otherwise teaching higher order thinking skills cannot go beyond designing 'intuitive' activities to engage in higher order thinking. Finding that teachers' declarative metacognitive knowledge of thinking skills is deficient even at the later stages of implementation, the researcher recommended to other researchers to consolidate teachers' declarative metacognitive knowledge of thinking skills before using for instruction. She suggested that this could be achieved by engaging teachers in activities including "reflecting upon their own thinking processes, analyzing what thinking skills are applied in the process of solving various problems, labeling thinking skills by names while discussing generalizations and rules regarding those skills" (Zohar, 1999, p. 428).

Baylor (2002) emphasized the importance of metacognitive awareness of teachers especially if they are inexperienced in instructional planning. Her findings supported the idea that increase in metacognitive awareness about instructional planning lead pre-service teachers to more in depth understanding of planning process; thus, result in better performance. Since PSTs also inexperienced in SSI teaching and technology integration into SSI teaching, making their metacognition online before, during and after teaching was assumed influential in their effective SSI teaching practices with technology.

2.1.3.2. Metacognitive framework of this dissertation

In this study, we used Teacher Metacognitive Framework (TMF) to explain PSTs' metacognition, because it is the most comprehensive framework explaining teacher metacognition including knowledge, belief, and goal components. Similar to Artzt and Armour-Thomas's (1998) operationalization of metacognition, in this study, metacognition referred to PSTs' commentaries about their teaching or about the processes associated with their teaching. Moreover, Artz and Armour-Thomas (1998) defined the components of teacher metacognition underlying instructional practice with "teaching as problem solving" perspective, which is compatible with the analogy of technology integration as wicked problem. Artz and Armour-Thomas (1998) defined eight components of metacognition which are knowledge, beliefs, goals, planning, monitoring and regulating, assessing and revising as it was explained in the first chapter. Knowledge, beliefs and goals were defined as overarching components of metacognition, which affect teachers' instructional practice. The other five components were defined as teachers' mental activities influencing their decision-makings before, during and after instructional practice. Combining the definitions of metacognition for teaching and learning, with some changes in operationalization of the constructs in TMF, the following framework was proposed to explain the teacher metacognition underlying technology-integrated instructional practice (Figure 4). The operational definitions of the components illustrated in Figure 4 were explained below.

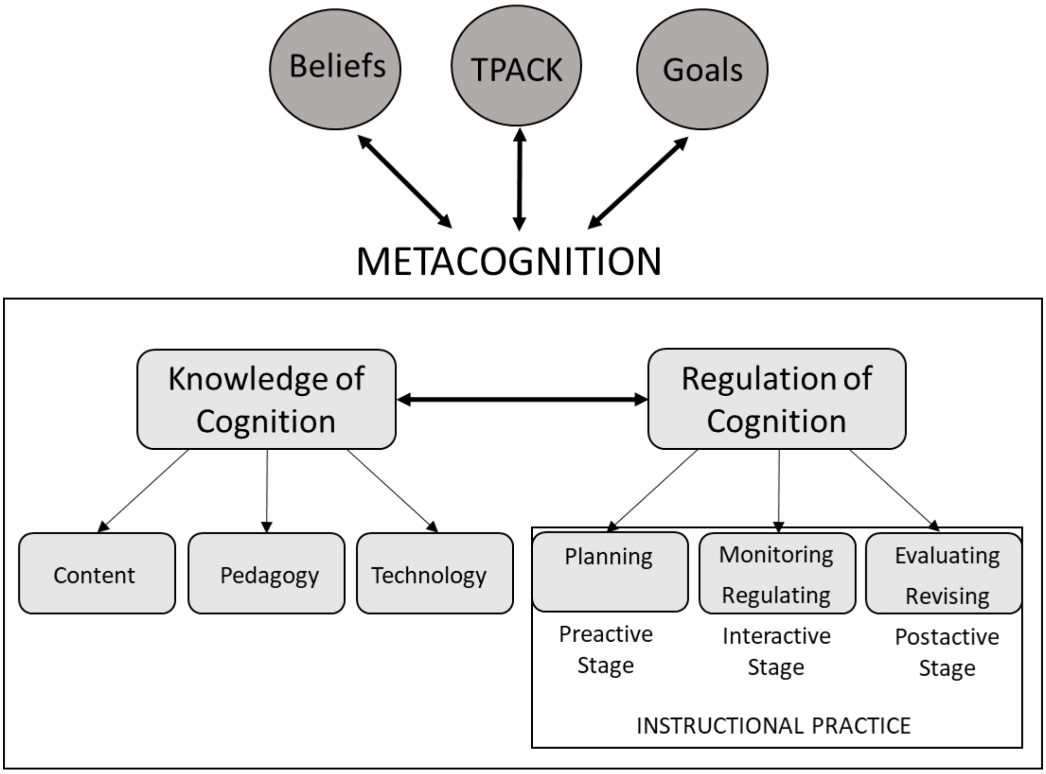

Figure 4. Teacher metacognitive framework proposed for this study

In Artzt and Armour-Thomas' (1998) model, knowledge was defined operationally as "an integrated system of internalized information acquired about pupils, content and pedagogy" (p.7). In the context of this study, we operationalized it as the knowledge required for technology integration into effective SSI teaching, which was called TPACK. Therefore, the knowledge mentioned in this study refers to TPACK of PSTs. Since the aim of this study was to develop PSTs' knowledge for effective SSI teaching with technology, the changes in their knowledge for effective SSI teaching with technology were elaborated in the fourth chapter. It was hypothesized that PSTs' theoretical knowledge about TPACK affects their metacognition underlying instructional practice. Conversely, it was also hypothesized that activating metacognition about instructional practice affects PSTs' theoretical and practical knowledge about TPACK. Moreover, in order to be able to engage in personal reflections about their knowledge states and abilities, which is defined as knowledge of cognition (Paris & Winograd, 1990, Table 4), PSTs should know the required knowledge and abilities defined in TPACK. Therefore, TPACK as a knowledge body was decided as an element that can affect and be affected from metacognition underlying technology integrated SSI teaching practice.

Another element affecting metacognition was defined as beliefs. The beliefs were defined as “an integrated system of personalized assumptions about the nature of a subject, its teaching and learning” (Artzt & Armour-Thomas, 1998, p.8). In the context of this study, PSTs’ beliefs about nature of SSI teaching with technology were included. Therefore, PSTs’ beliefs about the role of technology in SSI teaching, and teacher and student role in technology–enhanced SSI lessons were investigated. This element resembles one of the TPACK components, namely, an overarching conception about the purposes for incorporating technology in effective SSI teaching, since that TPACK component was operationalized as an overarching component determining all of the instructional decisions of PSTs. Similarly, belief was operationalized as an overarching component of teacher metacognition influencing PSTs thought in preactive, interactive and post-active stages of their SSI teaching.

The other element affecting metacognition, goals, was defined as “expectations about the intellectual, social and emotional outcomes for students as a consequence of their classroom experiences” (Artzt & Armour-Thomas, 1998, p.9). As it was mentioned above, SSI teaching has many outcomes including developing understanding of science and nature of science, increasing motivation and interest, and supporting argumentation practices (Sadler & Dawson, 2012). Moreover, by engaging students in technology-enhanced activities to teach SSI, PSTs also aim to contribute students’ scientific and technological literacy. Therefore, PSTs goals were inspected whether they had clear goals in SSI teaching through technology. Their stated goals were assumed influential again in their metacognition and instructional practice. According to our proposed model, these three elements, beliefs, TPACK and goals, were assumed to have two-directional relationship with teacher metacognition. These elements both affect and be affected from metacognition.

In addition to overarching components of metacognition, Artzt and Armour-Thomas (1998) defined actual enactment of the lesson as cognitive process and categorized teachers’ thinking processes about their teaching before, during and after teaching. Differently, we proposed additional components to teacher metacognition.

Considering the classification defined in the pioneering metacognition frameworks (Table 4), it was hypothesized that teacher metacognition can be classified as knowledge of cognition and regulation of cognition. Knowledge of cognition was defined as knowledge base of metacognition, while regulation of cognition reflects the process base of metacognition. Similar to Schraw and Moshman's (1995) definition of knowledge of cognition, it was defined as PSTs' knowledge about their own cognition. PSTs' knowledge about their knowledge that can contribute to their development SSI teaching practice with technology was operationalized as their knowledge of cognition. Therefore, knowledge of cognition was hypothesized to include three components, namely, content, pedagogy and technology. PSTs' knowledge about their SSI knowledge, pedagogical and technological knowledge related to SSI teaching were aimed to be investigated under these components. PSTs' judgments about their SSI, pedagogy and technology knowledge as well as their decisions about their knowledge after a monitoring process during their instructional practice were included in these components. However, after analysis of the data, a revision was done to the proposed model. Technology knowledge was decided to be removed from the knowledge of cognition, although PSTs' thinking about their technology knowledge and technology usage was still included in teaching processes. The rational for this revision was explained in Chapter 5.

Artzt and Armour-Thomas (1998) categorized teachers' teaching processes as preactive, interactive and post-active stages and defined teachers' thinking in preactive stage as planning, in interactive stage as monitoring and regulating, and in post-active stages as assessing and revising. Although the operational definitions of Artzt and Armour-Thomas (1998) concerning these components were employed without any change, assessing component was termed as 'evaluating' similar to Schraw and Moshman's (1990) terminology. Since proposed TPACK framework also include assessment, PSTs' judgments about the effectiveness of their instructional practice was decided to be termed as 'evaluating' in order to prevent any confusion.

As the literature on metacognition has highlighted, knowledge of cognition and regulation of cognition was hypothesized to be related to each other. Therefore, the relationship between them was assumed to be bidirectional. Similarly, the relationship of metacognition with TPACK, belief and goal elements were assumed to be bidirectional. Based on these proposed relationships, metacognition of PSTs was assumed to contribute their effective SSI teaching practices with technology. Therefore, in this study, PSTs judgments about their own content, pedagogy and technology knowledge; and their thinking in planning technology-integrated SSI lesson, monitoring and regulating while enacting their lesson plans, and evaluating and revising after their teaching performance was tried to be figured. Moreover, the interaction between their metacognitive patterns and TPACK for effective SSI teaching was sought.

2.2. Cycle 2: Determining the characteristics of the course design

This cycle was conducted to determine the characteristics of an effective course re-designed to develop PSTs' effective SSI teaching practices with technology by activating their metacognition. Therefore, different approaches to develop pre-service teachers' SSI teaching practices, TPACK and the empirical studies conducted with those approaches were reviewed in this cycle. Therefore, the following research question and the sub-questions were tried to be answered.

2. What are the characteristics of a course to develop pre-service teachers' effective SSI teaching practices with technology by activating their metacognition?
    a. How can pre-service teachers' effective SSI teaching practices with technology be developed?
    b. How can metacognition of pre-service teachers be activated?

2.2.1. Social constructivist learning environments

Social constructivist learning theory assumes that knowledge is constructed both individually and socially through the interpretations of experiences; therefore, instructions from social constructivist perspective should consist of experiences facilitating knowledge construction (Jonassen, 1999). In order to determine the characteristics of the social constructivist learning environment, it is better to summarize the characteristics of learning from social constructivist perspective.

Balancing the individual and social constructivist perspectives on learning, Hung and Chee (2003) determined the principles of learning. According to Hung and Chee (2003) there are eight principles of learning guiding social constructivist learning environments:

- Learning is demand driven or problem centered
- Learning is a social act/construction mediated between social beings through language, signs, genres, and tools
- Learning is an identity formation
- Learning is reflective and metacognitive
- Learning is embedded in rich cultural and social contexts
- Learning is interdisciplinary or multidisciplinary
- Learning is socially distributed between persons, rules, and tools
- Learning is to transfer knowledge from situations to situations discovering relational and associated meanings in concepts (pp. 400-401).

Based on these principles of learning, Hung and Chee (2003) determined the characteristics of an effective web-based learning environment. They emphasized the importance of richness of the learning environment in terms of the facilities for communication and accessing information resources. The tools embedded in the learning environments should help learners learn from each other through communicating and collaborating for a shared task. Moreover, they also pointed out the importance of embedding prompting questions for provoking reflection and metacognition. Furthermore, the researchers stated the importance of complementing the web-based learning environments with other forms of interactions like face-to-face interaction.

Jonassen (1999) suggested a model to design constructivist learning environment. The model was stated to be appropriate for problem solving in ill-defined or ill-structured domains. By integrating technology into SSI teaching, we assumed that PSTs were engaged in problem solving. Therefore, Jonassen's (1999) model of constructivist learning environment were considered in this study to re-design the undergraduate course. The model offers six methods including:

1. Select an appropriate problem (or question, case, project) for the learning to focus on.
2. Provide related cases or worked examples to enable case-based reasoning and enhance cognitive flexibility.

3. Provide leamer-selectable information just-in-time.
4. Provide cognitive tools that scaffold required skills, including problem-representation tools, knowledge-modeling tools, performance-support tools, and information-gathering tools.
5. Provide conversation and collaboration tools to support discourse communities, knowledge-building communities, and/or communities of learners.
6. Provide social/contextual support for the learning environment. (Jonassen, 1999, p.216)

Moreover, in order to support learning, Jonassen (1999) suggested instructional activities including modeling, coaching and scaffolding. Teachers were advised to model both the overt performance and covert cognitive processes by demonstrating how to perform and articulating the decision making during the performance. Moreover, it would be better if teachers coach the learners to increase their motivation, to facilitate monitoring and regulation and reflection. Teachers were also advised to scaffold the learners by adjusting task difficulty or restructuring the task.

There are common characteristics of the principles of designing social constructivist learning environment. First of all, there should be a problem, question or project to focus on and it should be appropriate for the learner to facilitate ownership of the learning (Jonassen, 1990; Savery & Duffy, 1994). Moreover, according to social constructivists, learning occurs through negotiation of the meanings; therefore, teachers should facilitate communication and collaboration (Jonassen, 1999; Savery & Duffy, 1994). With the help of different conversation and collaboration tools, learner can build knowledge through discourse communities.

Learning occurs in social environment. According to Vygotsky (1978) the development occurs when the learners approximate their actual developmental level to the potential developmental level through solving problems with the guidance of more capable others. Therefore, modeling, coaching and scaffolding are important instructional activities for teachers according to the social constructivists (Jonassen, 1999). Teacher should provide cases or worked examples to help learners increase their actual developmental level toward the potential level of development. Moreover, for this purpose teacher should model the target performance or project.

Social constructivist learning environments should have necessary resources or tools for learners to reach information, to negotiate their meaning with others and to collaborate in knowledge construction. Finally, learning is reflective and metacognitive (Hung & Chee, 2003). Therefore, teachers should provide tools to promote reflection and metacognition.

In this study, the purpose was to develop PSTs' effective SSI teaching practices with technology in the re-designed course. Therefore, we aimed to provide a social constructivist learning environment for PSTs to develop their SSI teaching practices in the re-designed undergraduate course. Moreover, since PSTs were expected to design and implement lesson plans for SSI teaching with technology, they were also expected to design social constructivist learning environments.

2.2.2. Development of pre-service teachers' TPACK

TPACK models offer us information about the conceptualization of effective teaching with technology. However, it does not provide a clear straightforward way to be followed to help pre-service teachers develop TPACK (Niess, 2012). Teacher preparation programs should be in search of the ways to provide and arrange learning experiences of pre-service teachers to help them gain the knowledge defined in the TPACK lens, since pre-service teachers do not have experience about learning content with the emerging technologies (Niess, 2012).

There are different approaches in the literature to develop pre-service teachers' TPACK (Lambert & Gong, 2010; Mishra & Koehler, 2006; Mouza, 2016; Mouza, Karchmer-Klein, Nandakumar, Yilmaz Ozden, & Hu, 2014). Many projects were granted and conducted in this area to transform teacher education programs throughout the last two decade (Hall, Fisher, Musanti, & Halquist, 2006; Mims, Polly, Shepherd, & Inan, 2006; Polly, Mims, Shepherd, & Inan, 2010). Polly et al. (2010) investigated the effectiveness of the projects conducted in the scope of Preparing Tomorrow's Teachers to Teach with Technology (PT3). This program provided grants for projects designed to transform teaching and learning through faculty development, course restructuring, certification policy changes, online teacher preparation, enriched-networked-virtual, video case studies, electronic portfolios, mentoring triads, or embedded assessment (U.S. Department of Education, 2006). Numerous project were designed to integrate technology into teacher education programs through one-on-one mentoring approaches. Although it requires time and resource, and not a suitable model for large-scale projects, these mentoring attempts were reported to be beneficial in terms of improving faculty's technology knowledge, increasing the frequency of integrating technology into method courses, and fostering pre-service teachers' use of technology during their coursework.

According to Polly et al. (2010), some projects attempted to develop TPACK of both preservice and in-service teachers concurrently. In these projects, K-12 teachers were provided assistance in planning and teaching technology-rich lessons, and the teacher education programs assigned the pre-service teachers into these schools to provide them technology-rich field experiences. Although these projects reported more positive attitudes toward technology, more frequent use of technology, and more technology integration into teaching of preservice teachers, difficulty of finding technology-rich field experiences restricted the applicability of the projects. Another theme emerged in the analysis was reported as designing curricula materials. Various PT3 projects designed K-12 units and modules for teacher education courses. In some cases, partnership between K-12 teachers and faculty was fostered and pre-service teachers and in-service teachers collaborated to design and teach technology-rich lessons.

Other projects aiming to create teacher education instructional materials either re-designed the method courses or tried to develop cases for modeling technology integration to the pre-service teachers. For example, In Integrating New Technologies Into the Methods of Education (INTIME) project, researchers developed a video vignettes database to exemplify technology use of teachers and students as a learning tool in a variety of subjects (Krueger, Boboc, Smaldino, Cornish, & Callahan, 2004). Polly et al. (2010) argued according to their analysis that providing "best practices" to pre-service teachers have the greatest impact on their instructional practices. Moreover, Gess-Newsome (1999) also suggested providing pre-service teacher good practices in teacher education program in order to develop their PCK from a transformative perspective. Therefore, providing video cases or instances to collaborate with teachers who integrate technology effectively would be promising in the initiatives of TPACK development of pre-service teachers.

As the variety among the approaches in PT3 projects, there are different approaches to develop pre-service teachers' TPACK in more recent studies. In this section, different approaches to develop pre-service teachers' TPACK were summarized.

2.2.2.1. Stand-alone educational technology courses or method courses

The most commonly used way of developing TPACK is through stand-alone educational technology courses (Mouza, 2016; Voogt et al., 2013). According to a survey conducted by Kleiner, Thomas, & Lewis (2007), in United States, out of 1,439 institutions with teacher education programs being surveyed, 85% of the institutions offered stand-alone educational technology courses with a credit ranging from one to four. Therefore, using these courses was considered as a convenient way to develop teachers' knowledge in integrating educational technologies into their instruction, designing project-based lessons involving educational technology, recognizing when a student with special needs would benefit significantly with the help of adaptive/assistive technology. There are different studies investigating the effect of stand-alone educational technology courses for desired outcomes. For example, Lambert and Gong (2010) accomplished a change in pre-service teachers' self-efficacy toward integrating technology in the classroom and belief in the value of using technology to enhance teaching and learning through stand-alone educational technology course which is re-designed around 21st century skills.

Similarly, Mouza and Karchmer-Klein (2015) re-designed a stand-alone educational technology course to address the challenge of curricular technology integration. The researchers utilized the five-step approach of technology integration proposed by Harris and Hofer (2009) while redesigning the educational technology course to prepare preservice teachers for curricular technology integration. Harris and Hofer's (2009) five basic steps to technology integrated planning includes (1) choosing learning goals, (2) making pedagogical decisions, (3) selecting activity types to combine, (4) selecting assessment strategies, and (5) selecting tools and resources. Mouza and Karchmer-Klein (2015) also provided pre-service tehacers the best practices as suggested in the review of Tondeur et al. (2012).

Tondeur et al. (2012) reviewed 19 qualitative studies with the aim of preparing pre-service teachers for technology integration. In result of the meta-ethnography, they reached seven key themes related to preparation of pre-service teachers and five key themes related to conditions necessary to implement such programs at the institutional level. The key themes related to the preparation of pre-service teachers are (a) aligning theory and practice, (b) using teacher educators as role models, (c) reflection of attitudes about the role of technology in education, (d) learning technology by design, (e) collaborating with peers, (f) scaffolding authentic technology experiences, and (g) moving from traditional assessment to continuous feedback. Following the research-based principles, Mouza and Karchmer-Klein (2015) shifted the focus of educational technology course from technology to the curriculum by utilizing five-step approach for the adoption of TPACK framework. As a result based on the reflections of the students about the re-designed educational technology courses, Mouza and Karchmer-Klein (2015) concluded that the key components of the re-designed course were beneficial in promoting awareness about the importance of using technology aligned with content and pedagogy. On the other hand, the researchers previse others about the possible insufficiency of stand-alone educational technology course in fostering the depth of understanding based on the pre-service teachers' responses about their future uses of technology. For this reason, they urged the need to investigate the effect of their instructional practices and the stand-alone educational technology course on pre-service teachers' learning of technology, pedagogy and content. Moreover, Polly et al. (2010) also identified the weakness of this approach in developing pre-service teachers' ability to apply their technological skills into classroom experiences.

Similar to stand-alone technology courses, method courses was also used for TPACK development in different studies. While stand-alone technology courses aims to transform pre-service teachers' TPK into TPACK, method courses aim to transform PCK into TPACK or simultaneous development of PCK and TPACK. The results of the study conducted to compare the TPACK development of PSTs in stand-alone technology course and technology-infused method courses even support this transformation (Buss, Wetzel, Foulger, & Linday, 2015). Buss et al. (2015) found that PSTs' TPACK was developed in both type of course, but the growth rates of TPACK dimensions differ. Although PSTs showed a faster growth in TK and TPK in stand-alone course, they showed a faster rate of growth in PK and CK in technology-infused methods course. Buss et al. (2015) attributed these differences in the outcomes to the focus of the courses that stand-alone technology courses had a much stronger focus on technology while methods courses put more emphasis on pedagogy and content.

Ozgun-Koca, Meagher and Edwards (2010) found about the role of method courses on TPACK development that using advanced technologies in method course puts PSTs in a position of being learners, which in turn, foster the development of TCK, and reflect on their PCK and CK. Ozgun-Koca et al. (2010) investigated pre-service secondary mathematics teachers' TPACK development in the context of method course in which they introduced inquiry-based learning with a considerable emphasis on advanced digital technologies. The researchers asked pre-service teachers to prepare five secondary mathematics activities for using digital technologies and encourage them to use these activities in their field experience. They collected data through five secondary level mathematics activities, field experience reports and surveys. At the end of the course, Ozgun-Koca et al. (2010) reached a conclusion that pre-service teachers' perceptions about the technology shifted from viewing it as a reinforcement tool to a tool for developing mathematical concepts. Moreover, the researchers argued that PSTs' identity also shifted from learners of mathematics to teachers of mathematics. However, although advanced digital technologies were used to promote inquiry-based learning in the research, the researchers found that PSTs have still doubts about the role of technology in mathematics education. The researchers suggested other researchers to develop PSTs' TPACK in method courses as well as in field placement, which gives opportunity to provide exemplary technology integration in mathematic teaching.

Lowder (2013) also tried to develop pre-service teachers' TPACK in science method course. The researcher used pre-post surveys, pre-post lesson plans, interviews, student reflections and researcher reflections to figure out in what ways PSTs'

TPACK changed and to decide the teaching strategies and learning activities to support TPACK development. The researcher found that PSTs' general understanding of technology integration practices increased. In light of student reflections, the researcher suggested to introduce TPACK framework first in educational technology courses before coming to the method course. Moreover, the researcher proposed a method course specific to technology integration and recommended other method courses to include technology integration. The participants of the study completed introductory coursed about educational technology, educational psychology and introduction to teaching and the study was conducted in the first methods course.

In Holmes's (2009) study, participants were selected from upper grades. Specifically, the participants were senior undergraduate secondary mathematics pre-service teachers so that the participants were able to prepare lesson activities successfully by using their existing pedagogical and mathematical knowledge and the knowledge about interactive whiteboards that they learned in the scope of the study. The researcher admired the advantage of PSTs' existing knowledge in terms of integration of their knowledge of technology, pedagogy and content; however, the researcher also warned about the possible advantages of introducing interactive whiteboards in earlier courses of the undergraduate program.

The studies mentioned above showed that enrollment to either educational technology course or method course with an aim of developing TPACK seems to be promising to develop PSTs' TPACK but have limitations. As it was found in the study exploring the differences of the outcomes of stand-alone technology course and method course (Buss et al., 2015), pre-service teachers' TPACK development could be centered on technology or pedagogy knowledge due to the focus of the courses. However, in this study, the main purpose was to develop PSTs' technology integration knowledge to increase the quality of their SSI teaching. Therefore, rather than centering PSTs' TPACK development on the technology or pedagogy, the main focus was developing their TPACK specifically for SSI teaching by transforming their pedagogy and technology knowledge into TPACK for effective SSI teaching. The literature review studies also indicated the potential of the studies re-designing and enacting technology-enhanced lessons in developing PSTs' TPACK (Voogt et al., 2013).

Considering the affordances and limitations of educational technology courses and method courses in developing TPACK, a stand-alone course was re-designed with a focus of technology integration into SSI teaching.

Moreover, the re-designed course is offered at the last year of the teacher education program. That is, PSTs completed all science-related and technology-related courses as well as general pedagogy and method courses specific to science teaching. By this way, pre-service teachers could have opportunity to transform their already obtained content, pedagogy and technology knowledge into TPACK for effective SSI teaching. For these reasons, a stand-alone SSI teaching course was decided to be re-designed to develop PSTs' TPACK for effective SSI teaching. The processes followed in re-designing such a technology-enhanced course was explained in this chapter.

2.2.2.2. Learning by design approach

Another common approach for developing TPACK is "learning technology by design" approach. This approach was utilized to develop TPACK of faculty members (Koehler et al., 2004; Koehler & Mishra, 2005a, 2005b; Koehler et al., 2007; Rienties, Brouwer, & Lygo-Baker, 2013), in-service teachers (Guzey & Roehrig, 2009; Jimoyiannis, 2010; Jimoyiannis, Tsiotakis, Roussinos, & Siorenta, 2013; Koehler, Mishra, Bouck, DeSchryver, & Kereluik, 2011; Koh & Divaharan, 2011; Prieto, Villagrá-Sobrino, Jorrín-Abellán, Martínez-Monéz, & Dimitriadis, 2011) and pre-service teachers (Agyei & Voogt, 2012; Angeli & Valanides, 2009; Chai, Koh, & Tsai, 2010; Chien, Chang, Yeh, & Chang, 2012; Graham, Borup, & Smith, 2012; Koh & Divaharan, 2011, 2013; Mouza et al., 2014; Pamuk, 2012).

Koehler et al. (2004) critiqued the techniques like workshops or technical support group that have been developed and implemented in teacher education institutions to develop TPACK in terms of their simplistic nature. They claimed that dividing the labor among faculty members and technology programmers in developing online courses effects pedagogy negatively because faculty members often do not know enough about the possibilities of the technology designed by technology producers. On the other hand, participating in the design process gives opportunity for teachers to be involved in authentic problem solving with technology (Koehler & Mishra, 2005a). The researchers claimed that teachers bring technology, content and pedagogy together by designing, because when they involved in the act of design, teachers develop a technology compatible with the subject matter to be taught and the certain instructional goals rather than learning the technology in a more generic manner. According to the survey results they implemented before and after graduate students were involved in authentic design-based activities, participants started to perceive CK, PK, and TK as more integrated and inter-related entities rather than seeing CK, PK, and TK as useful constructs in and of themselves (Koehler & Mishra, 2005b).

There are studies involving teachers in collaborative design act for technology or curriculum materials. Koh et al. (2014) investigated teachers' design talk during the group-based design sessions and concluded that the composition of design team should be considered, because they found that the team including an experienced educational technologist as a facilitator addressed more TPACK in their discussions. In Kafyulilo, Fisser and Voogt's (2014) study 12 secondary science teachers participated in workshops and prepared technology-enhanced biology, physics and chemistry lessons in their design teams. Teachers made animations in PowerPoint and prepared instructional videos. Then teachers implemented their designed lessons and all teachers reflected on their practices. The results of the study indicated that teachers' technology integration knowledge and skills increased at the end of the interventions. Kafyulilo et al. (2014) claimed that collaborative design team practices were promising for teachers in terms of sharing knowledge, skill, experience and challenges they faced in technology-enhanced teaching. Boschman, McKenney, and Voogt (2015) investigated the nature of design talk of teachers' design team during the design of technology-rich early literacy activities. They reached a conclusion that teachers spent most of their times for PCK and TPACK, and they addressed PCK or TPACK mostly when they are talking with their practical concerns.

Teachers may be involved in design processes in different extents. In their study, Cviko, McKenney and Voogt (2014) assigned different roles to the participating teachers, namely, executor-only, re-designer, and co-designer. The executer-only teachers were supposed to implement ready-made instructional materials, while re-designer teachers were supposed to re-design already existing material collaboratively, and co-designer teachers designed new materials. Teachers' assigned roles affected their perceptions and the extent of integration of technology-rich activities. The researchers found that teachers concerned about the practicality of technology when they were assigned executer-only and re-designer roles. Moreover, the extent of technology-rich activity integration was detected to be higher in co-designer role, while it was lowest in the executor-only role. On the other hand, teachers in each role reached significant learning gains. Therefore, it can be implied that involving teachers in designing process as an active agent is important for promoting technology integration.

Although learning technology by design approach is common in in-service teacher professional development studies, there are also studies conducted with pre-service teachers utilizing this approach (Alayyar, Fisser, & Voogt, 2011, 2012; Agyei & Voogt, 2012). Alayyar et al. (2011) formed design teams including a group of pre-service teachers working together in collaboration to design solutions to the authentic problems they encountered during their in-school trainings by using ICT. At the end of the intervention, the researchers detected a positive change in all TPACK dimensions except for CK with medium or large effect sizes. It may be implied that working in design teams for learning ICT by design was a fruitful way of developing a deeper understanding of pre-service teachers' TPACK.

Alayyar et al. (2012) conducted a further study to investigate the potential of blended support to the design teams to meet the needs of the participants stated in the study of Alayyar et al. (2011). Pre-service teachers indicated the need for a more accessible support in an environment with their mother tongue and could be reached any time (Alayyar et al, 2011). Therefore, Alayyar et al. (2012) conducted an experimental study in which one of the groups was provided with only face to face support, while other group was provided support with an online learning management system including variety of properties like tutorials about the uses of software, exemplary lesson plans, informative links and repertoire of ICT, chat tool and so on. The elements of the blended support were found to be effective by the participants.

However, the researcher could not find any significant difference between blended support and face to face support in developing participants' attitude, ICT skills, and TPACK components, except TK and TPK, while blended support fostered higher gains in attitudes towards ICT. Therefore, it can be summarized from these two studies that any form of support is helpful for design teams.

In a similar study, Agyei and Voogt (2012) formed design teams of pre-service mathematics teachers in experimental group to find a technological solution to an authentic pedagogical problem. These design teams designed technology-enhanced lesson materials collaboratively and implemented the designed materials in their micro-teachings. To Agyei and Voogt (2012), although getting involved in design teams in designing technology-enhanced curriculum materials improved PSTs' technology integration skills and an understanding of learner-centeredness approach, PSTs faced with challenge in managing the time in their implementations of designed lessons.

Baran and Uygun (2016) generated a set of principles of design based learning (DBL), which they called as TPCK-DBL, to develop TPACK in pre-service and in-service teacher education context. They listed the following eight design principles as "brainstorming of design ideas, design of technology-integrated artifacts, examination of design examples, engagement with theoretical knowledge, investigation of information and communication technology (ICT) tools, reflection on design experiences, applying design in authentic settings, and collaboration within design teams" (Baran & Uygun, 2016, p. 48).

To sum up, learning by design approach provide both pre-service and in-service teachers an opportunity to develop knowledge not just of technology, content and pedagogy, but also of their relationship to each other by providing a possibility to produce a solution with technology to an authentic pedagogical problem. Arranging design teams to work collaboratively provide a learning environment through sharing knowledge, experiences or challenges among teachers. The design talk in these design teams reflects teachers' TPACK, especially when they are discussing their practical concerns. However, in order to increase the potential of design teams in increasing an understanding of TPACK, the composition of the team and the role of the teachers in designing should be carefully considered. Moreover, the nature of the support provided to the design team affects the attitudes toward ICT, while any kind of support effect the development of ICT skills and TPACK components in a positive way. Lastly, implementing the designed curriculum material is important, but time management can be considered as an important challenge to be faced while implementing.

By considering the challenges and opportunities of learning by design approach, we decided to engage PSTs into design process collaboratively. They were asked to design technology-enhanced lesson plans and enact these lesson plans in the course with their design teams. While designing lesson plans, they were facilitated to design instructional materials for different purposes collaboratively. They designed presentations with different presentation tools, videos or blogs to be used in SSI teaching. Moreover, in order to increase the efficiency, the instructor and teaching assistants of the course provided support to the design groups through learning management system and face-to-face communications.

2.2.2.3. Case-based learning

Case-based learning was argued as a promising approach in promoting TPACK development of both pre-service and in-service teachers (Mouza, 2011; Mouza & Karchmer-Klein, 2013, 2015; Mouza & Wong, 2009). The researcher found that it is helpful in terms of developing an understanding of the relationships between technology, pedagogy and content, and engaging teachers in reflection so that teachers learn from their practice. It was stated to be congruent with the situated nature of TPACK. Since teachers analyze and reflect on their own practice, the teaching cases reflect the local context in terms of curriculum goals, needs of the students and the available resources (Mouza, 2011).

Cases can function as exemplars of good teaching practice, opportunity to practice problem solving or a way of self-reflection. Mouza and her colleagues used cases as a way for personal reflection. In their studies, pre-service or in-service teachers were expected to design and implement a technology-integrated lesson; then, they analyzed and reflected on their enactment of the technology-integrated lesson by writing case reports. Thus, they were engaged in a detailed reflection that enables them learning from practice (Mouza & Karchmer-Klein, 2013). Reflecting upon their practice by writing ensured a more systematic reflection so that participants gave meaning to their experiences. This approach was argued to be important for pre-service teachers to make intuitive changes in their thoughts about the relationships among technology, pedagogy and content (Mouza & Karchmer-Klein, 2013).

Cases can also be used as a means for providing exemplars of effective technology integration. As mentioned before, in the INTIME project conducted by University of Northern Iowa, the project staff created video-cases to model technology integration in K-12 setting to share with pre-service teachers (Krueger et al., 2004). Video-cases can be used to help pre-service teachers reflect on classroom practice that they cannot experience (Cannings & Talley, 2002).

Considering its potential to contribute TPACK developments of PSTs for effective SSI teaching, in this study, cases were used for two purposes; providing exemplars and guiding personal reflections. In order to provide exemplar of effective technology integration, one of the video-cases created in INTIME project was used in the observation stage of the re-designed course. The video-case was showed and PSTs were asked to engage in discussions by answering the provided pre-viewing and post-viewing discussion questions in the website of INTIME. Moreover, cases were used as a means of personal reflection. PSTs were expected to design and implement an SSI teaching lesson plans. Then, they were asked to analyze the teaching performance videos and reflect on their performances as well as other groups' performances by answering the provided prompting questions.

2.2.2.4. Integrated approach

While the approaches mentioned above provide an insight about TPACK development, some of the researchers acknowledged the necessity of investigating TPACK development throughout the entire teacher preparation programs (Mouza et al., 2014; Niess, 2005, 2015). However, TPACK development within entire teacher education programs was not frequently studied in the literature (Mouza, 2016).

Niess (2005) critiqued the teacher education programs which depend on single course with the focus of learning *about* technology. The researcher argued that since TPCK is the integration of T, P, and C, teacher education programs need to employ more integrated approach to foster the development of TPACK. Niess (2005) investigated TPACK development of 22 student teachers throughout the 1-year graduate program guided by four themes namely, research-based teaching and learning, technology integration (TPCK), PCK development, and instructional practice integrated with campus-based coursework.

Hofer and Grandgenett (2012) carried out a longitudinal study to obtain in-depth information about TPACK development of secondary pre-service teacher in a three-semester graduate program. They collected both survey data and lesson snapshot and reflection assignments four times, and lesson plan documents two times. The analysis of surveys, reflections, lesson plans revealed a significant development of the participants' TPK and TPACK; however, they found that PSTs showed only limited growth in TCK. The highest growth rate in TPACK dimensions was detected in the fall semester during which PSTs enrolled in educational technology course and the first teaching method course, and were assisted in thinking about teaching strategies, instructional planning and technology integration simultaneously. With the help of simultaneously given technology and method courses, PSTs were given chance to get feedback on their technology integration planning form both perspective of educational technology and teaching in their discipline (Hofer & Grandgenett, 2012). The researchers recommended searching TPACK development throughout the program within variety of courses like science content courses as well as education and method courses. They argued that investigating TPACK development longitudinally with multiple data sources provide promising information about the pathway of TPACK development and give feedback to the programs for planning critically to prepare students for an increasingly technology-infused workplace effectively.

Mouza et al. (2014) proposed the integrated approach which includes the integration of technology courses, method courses and field experiences as an effective way of TPACK development that meets the markers of effective teacher preparation described in Tondeur et al. (2012). They found through the analysis of both qualitative and quantitative data that participants experienced significant gains in TPACK. Moreover, the researchers stated that all of the participants of the study successfully applied their knowledge to classroom practice. Moreover, it is argued that PSTs' TPACK level developed from recognizing level to accepting level and most of them moved to the adapting level and a few developed to the exploring level. Mouza et al.'s (2012) study also give insight about how such developments occurred by giving information about the contributions of the courses to the development of TPACK constructs.

Mouza, Nandakumar, Yilmaz Ozden, & Karchmer-Klein (2017) conducted a longitudinal study in which they tracked the TPACK development of pre-service teachers throughout the undergraduate teacher education program. They collected data with TPACK survey four points in time and searched for the changes in TPACK dimensions. The researchers found that there was a meaningful increase in all TPACK dimensions from freshman year to senior year. However, knowledge gains were not retained as PSTs progressed through the program. Even, they found statistically significant declines in TPACK dimensions from second year to third year except for PK, CK, and PCK. The decline in TPACK from second year to third year was explained with the lack of opportunity to observe, practice and model effective integration of content, pedagogy and technology in content courses. Mouza et al. (2017) declared that pre-service teachers' TPACK was increased substantially when they enrolled in method courses in which they have opportunity to integrate technology authentically within content based instruction. Combining the quantitative data with the qualitative data gathered via blog entries and case reports, the researchers reached a conclusion that intentional educational technology coursework is important for TPACK development. Moreover, they suggested that providing effective models of TPACK across university faculty and cooperating teachers is vital to retain the knowledge gains over time.

Although restructuring the whole teacher education program in an integrated way was found helpful in developing TPACK, the contribution of the courses, in which pre-service teachers were provided opportunity to integrate technology authentically within content-based instruction, was emphasized (Mouza et al., 2017). Moreover, providing effective models of TPACK was considered vital to ensure knowledge gains throughout the integrated programs. Therefore, to increase the effectiveness of the whole program in TPACK development, including these opportunities within courses was also important. For these reasons, in this study, one-semester undergraduate SSI teaching course was decided to be re-designed to develop PSTs' TPACK for effective SSI teaching. Considering the availability of the time and resources, and the advantages and disadvantages of each approach to TPACK development, and recommendations offered in literature about the potential of re-designing technology-enhanced courses, a single one-semester course with a focus of SSI teaching was re-designed. PSTs' were given chance to learn what SSI is, how to teach it and how technology can be integrated into this process with the designed activities in this course. Moreover, in the light of the results, implications for the whole teacher education program were provided.

2.2.3. Activating metacognition

Studies showed that pre-service teachers' or teachers' metacognition can be activated and developed through different activities offered in courses (Eldar, Eylon, & Ronen, 2012; Zohar, 2012). Eldar et al. (2012) found that metacognitive teaching strategies used in the course offered in science teacher education program promoted PSTs' content and pedagogical content knowledge. Based upon the research studies indicating that learning outcomes are improved when metacognitive processes are increased, Eldar et al. (2012) tried to improve PSTs' construction of desired PCK by activating their metacognition. Therefore, in the context of a disciplinary course, they tried to develop PSTs' content knowledge and PCK, and they tried to figure out the role of metacognition and the types of metacognitive scaffolding in their learning.

Zohar (2012) showed that a professional development course could help teachers develop meta-strategic knowledge when if it consists of explicit instruction rather than teaching intuitively. Persuading the learners for the positive effect of metacognition on their learning was considered as an important strategy to activate metacognition. Asking learners to think about what they are doing would not convince them to do so without offering the potential learning gains (Thomas & McRobbie, 2001). After engaging the metacognitive processes, the learners should be facilitated to reflect on the utility of these processes for their learning. Therefore, in the comprehension phase of the re-designed course, the importance of metacognition in developing necessary knowledge for technology integration was explained by giving examples from the literature. Moreover, they were informed about how they can think metacognitively in different phases of their technology integration practices.

In the classrooms with a focus on metacognitive learning, students are asked to make their prior knowledge explicit and monitor the progress of their conceptions and ideas continuously in the course (Blank, 2000). The common way of accomplishing this monitoring is to ask students write what they think and how they reached that kind of thinking or analyze the recordings of their responses in classroom activities (Blank, 2000). Eldar et al. (2012) also found that asking PSTs to write structured reflection as a metacognitive instructional strategy is very helpful in developing their PCK. Eldar et al. (2012) showed that PSTs who were asked to write reflection after each lesson identified significantly more characteristics of the instructional strategies as compared to PSTs who did not write any reflection. Similarly, the role of reflection was also frequently emphasized in TPACK development studies (Gao, Chee, Wang, Wong, & Choy, 2011; Jang & Chen, 2010; Kopcha, Ottenbreit-Leftwich, Jung, & Baser, 2014). Therefore, the role of reflection in activating metacognition is important for TPACK development and scaffolding in written documents is necessary for activating metacognition. For this reason, PSTs were asked to write reflection papers in this study. In order to increase the effectiveness of the reflections, they were provided prompting questions to shape their reflection papers. One of the purposes of the first and last reflection papers was to make PSTs prior knowledge explicit and to monitor their knowledge development. In these reflection papers, PSTs were prompted to rate their CK, PK, TK and TPACK with their rationales for the ratings.

Since social interaction has influence on the learners' knowledge construction, socially shared metacognition was also stated to be effective in learning of problem solving (Eldar et al., 2012). By allowing students to share various ideas and ways of thinking during an inquiry learning process and to negotiate the differences in their opinions, a metacognitive-guided inquiry learning environment can be created (Zion, Michalsky, & Mevarech, 2005). Therefore, PSTs should be facilitated to work collaboratively and guided for socially shared metacognition by helping them to negotiate their ideas with others. In this study, in the comprehension and observation stages of the re-designed course, PSTs were allowed to discuss their opinions with each other and in the reflection papers, they were asked about the changes in their thoughts in these discussions. Moreover, they were interviewed as a group in VSRIs so that they shared their metacognitive thoughts with their group members.

2.2.4. Initial design principles

Considering the principles of social constructivist learning environment and recommendations provided in the literature about developing TPACK and activating metacognition, initial design principles were constructed to determine the characteristics of the re-designed course for developing PSTs' SSI teaching practices with technology.

> Design Principle 1 (DP1): PSTs should be guided to select an SSI topic relevant and meaningful to teach and learn.

PSTs were expected to select an SSI topic and design a lesson plan to enact in the course. Therefore, they were expected to design a social constructivist learning environment to teach SSI. According to Jonassen (1999), constructivist learning environments can be designed to support issue-based learning. However, providing interesting, relevant and engaging problems is key to the ownership of the learning goal. Therefore, the selected issue should be relevant both for PSTs to teach and for the target students to learn.

Moreover, to design a constructivist learning environment, Jonassen (1999) suggested to select ill-defined problems or issues. SSI consist of ill-structured and open-ended real world problems (Sadler & Dawson, 2012) so that students can construct knowledge through social negotiation.

> Design Principle 2 (DP2): PSTs should be guided to consider the role of students' epistemological views including NOS beliefs in their decision-making in SSI.

Students' epistemological orientations about nature of science were considered as important in their responses to SSI topics (Simmon & Zeidler, 2003; Zeidler et al., 2005). Students evaluate the evidences based on their belief systems. Moreover, students' decision making in SSI topics resembles to decisions engaged by scientists, therefore, considering students' views about nature of science during the evaluation of scientific data regarding social issues was claimed to be important in SSI teaching. Therefore, PSTs should be facilitated to consider their students' epistemological beliefs and to develop NOS understanding of students in order to increase the quality of discourse.

> Design Principle 3 (DP3): PSTs should be guided to create learning environments that facilitates the construction of shared social knowledge via discourse about SSI.

Rich and diverse classroom discussions are important in promoting scientific literacy. Engaging in argumentative discourse including the decisions about moral and ethical issues was considered as prerequisite for the development of scientific literacy (Zeidler et al., 2005). Finding pedagogical strategies to facilitate social interaction in the science classrooms has vital importance to engage students in reasoning through argumentation. Using argumentation was considered as a useful means to engage students in thinking and reasoning process, as well as imitate the daily life discourse practices in the development of scientific knowledge (Zeidler & Nichols, 2009). Therefore, PSTs should be facilitated to create learning environments in which students are given opportunity to evaluate evidences as well as thoughts through argumentative discourses.

Design Principle 4 (DP4): PSTs should be guided to include moral and ethical dimensions into their SSI teaching.

In the resolution of SSI, students use their culturally developed norms and values. Researchers indicated that students are moral agents and their emotions, care and empathy are influential in their resolution of SSI (Sadler & Zeidler, 2004). They develop empathy with the characters involved in the SSI scenario. Moreover, their empathy toward their friends, family and other relatives who were faced with the situation mentioned in the scenario may affect their decision-making. Therefore, their cultural background, moral developmental level, and gender are influential in their resolution of SSI. For this reason, teachers should include moral discourse in their SSI teaching to include care, emotion and contextual factors so that they can contribute students' identity formation (Zeidler et al., 2005).

Design Principle 5 (DP5): Concepts and theories about the pedagogy of SSI teaching and technology integration should be discussed explicitly.

In order to develop PSTs' effective SSI teaching practices with technology, concepts and theories about the pedagogy of SSI teaching and technology integration should be discussed explicitly. It is not enough to teach about SSI implicitly in teacher education program and hope PSTs to implement it in their future classroom practices (Pedretti, 2003). Rather, PSTs should be equipped with pedagogy of SSI teaching through theoretical discussions about the components of SSI teaching.

By this way, PSTs can test their knowledge development and evaluate their teaching performance. Theoretical models of SSI teaching and technology integration can be helpful in guiding PSTs' performances. Therefore, teacher education programs should help PSTs develop a strong theoretical underpinning and justification for teaching SSI (Pedretti, 2003).

Moreover, Angeli and Valanides (2009) stated that "teachers need to be explicitly taught about the interactions among technology, content, pedagogy, and learners" (p. 158). Research shows that explicit teaching of characteristics of TPACK is required for successful technology integration (Jaipal-Jamani & Figg, 2015). Therefore, concepts and theories about SSI teaching and TPACK should be taught explicitly.

Design Principle 6 (DP6): Attempts to develop PSTs' effective SSI teaching with technology should align theory and practice.

According to social constructivist view, learning occurs when learners actively reorganize their ways of thinking and participate in classroom practices (Hung & Chee, 2003). As Brown (1998) stated, "The central issue in learning is becoming a practitioner, not learning about practice" (p. 230). PSTs should also be given opportunity to practice their understanding about the principles of SSI teaching. Teacher education programs should provide PSTs opportunity to design, implement and assess SSI teaching practices (Pedretti, 2003).

Moroever, Tondeur et al. (2012) conducted a meta-ethnographic analysis of 19 qualitative studies for systematic review about pre-service teacher trainings. One of the key themes about preparation of pre-service teachers was found as aligning theory and practice. Therefore, effective approaches to pre-service teacher preparation should include both theoretical information about the concepts or theories and the practical works about them. Tondeur et al. (2012) stated that the studies including short lectures or demonstrations and practical work was found more effective for pre-service teachers.

Design Principle 7 (DP7): PSTs should be facilitated to collaborate with peers.

Social constructivist learning environments should support collaboration (Jonassen, 1999), because in the definition of zone of proximal development concept, potential developmental level can be determined through problem solving in collaboration with more capable peers (Vygotsky, 1978). Collaboration for solving problem solving requires shared decision making which results in socially shared knowledge-construction. Therefore, collaborative problem solving was considered as one of the most important element of social constructivist learning environment.

Pre-service teachers should also be provided opportunities to collaborate with their peers. In order to help their learning about educational uses of technology, pre-service teachers should be facilitated to discuss and share their thoughts with their peers (Hu & Fyfe, 2010; Tondeur et al., 2012). In order to encourage collaboration, the learning environment should include necessary tools. The learners should be able to write notes to the teacher and to the others about the project (Jonassen, 1999). Online environments can be used as the medium for sharing and discussing their ideas so that meanings can be socially negotiated.

> Design Principle 8 (DP8): PSTs should be provided role models of effective SSI teaching with technology.

The main argument of social constructivists is that learning occurs with the guidance of more capable others. For this reason, modeling is suggested for social constructivist learning environments, because it offers learners examples of the desired performance (Jonassen, 1999). Jonassen (1999) stated that the best way of modeling in problem solving is providing worked examples, which offers a description of how problems are solved by experienced problem solvers. Since teaching SSI with technology requires also solving a pedagogical problem, providing role models indicating how effective SSI teaching with technology can be accomplished was also considered as important. Moreover, Gess-Newsome (1999) suggested teacher education programs with transformative PCK development view to provide examples of best practices for pre-service teachers.

As Tondeur et al. (2012) found, pre-service teachers become motivated to use technology when they observe teachers' or teacher educators' technology usage. Cases can also serve as exemplars of technology usage (See 2.2.3.3 Case-based learning). Therefore, modeling technology integration is important to increase PSTs' motivation to use technology in their teaching practices.

> Design Principle 9 (DP9): PSTs should be scaffolded in their SSI teaching with technology experiences.

Jonassen (1999) suggested three main instructional strategies for social constructivist learning environments, which are modelling, coaching and scaffolding. While modelling focuses on the expert's performance and coaching focuses on the learners' performance, scaffolding provides more systematic approach to support learners. It includes any kind of support for learners' performance. The knowledge construction of the collaborative community of learners can be mediated by providing appropriate scaffolding through the facilities of learning environment (Trinidad, 2003).

Scaffolding was argued to affect learners both cognitively and emotionally (Dennen, 2004). Different assists like hints, models, or demonstrations support learners cognitively, while support provided to learners help them cope with the feeling of failure. However, these scaffolding should be directed to the learners at their current ability level within their zone of proximal development (Dennen, 2004)

Moreover, pre-service teachers' observations on technology use are not enough to test their own knowledge and skills. They need opportunities to apply their knowledge (Tondeur et al., 2012). With experiences in technology use, pre-service teachers get a sense of achievement. To increase the effectiveness of authentic technology experiences, pre-service teachers should also be scaffolded in their planning and enactment of technology-enhanced SSI teaching.

Therefore, scaffolding PSTs' performances was considered important to increase their effectiveness in SSI teaching with technology. Learning management system can be considered an effective tool in scaffolding PSTs' knowledge construction. Moreover, face-to-face support provided by the instructor was assumed to be helpful.

When learners gain independence and do not need support to complete the cognitive task, fading of scaffolding should occur (Dennen, 2004). Therefore, since PSTs were assumed to gain enough experience to prepare effective learning environments to teach SSI with technology collaboratively, at the end of the semester, they were expected to prepare lesson plans individually without any support.

Design Principle 10 (DP10): PSTs should be engaged in critical reflection about their technology-integrated SSI teaching practices.

In order to support learning in social constructivist learning environments, researchers suggested to provoke reflection on what is learned and on the learning process (Hung & Chee, 2003; Jonassen, 1999; Savery & Duffy, 1994). In order to coach the learners' learning by provoking reflection, Jonassen (1999) suggested to:

- ask the learners to reflect on what they have done,

- ask the learners to reflect on what assumptions they made,
- ask the learners to reflect on what strategies they used,
- ask the learners to explain why they made a particular response or tool an action,
- ask learners to confirm an intended response,
- ask learners to state how certain they are in a response,
- require learners to argue with the coach,
- provide puzzles that learners need to solve which will lead to appropriate performance (pp. 233-234).

Promoting PSTs to reflect-on-action and to analyze their performance supports knowledge construction as well as metacognition. Therefore, engaging PSTs in critical reflection was also assumed to be important to activate their metacognition about their instructional practice. In order to provoke reflection, Jonasson (1999) suggested replaying learners' performance through video-records and think alouds.

Moreover, the role of reflection on TPACK development was also emphasized in the literature. Reflecting on the role of technology in education is important for pre-service teachers to get benefit from the TPACK development courses (Tondeur et al., 2012). Some activities like discussion groups, observation and writing was suggested to help pre-service teachers for reflection.

> Design Principle 11 (DP11): PSTs' metacognition about their technology-integrated SSI teaching practices should be activated by stating the effects of being engaged in metacognitive processes on their development explicitly.

From a social constructivist perspective, learning is reflective and metacognitive (Hung & Chee, 2003). In a social constructivist learning environment, when solving a problem, learners should be encouraged to monitor their own understanding at a metacognitive level (Savery & Duffy, 1994). Moreover, Baylor (2002) emphasized the importance of teachers' metacognition especially if they are inexperienced in instructional planning. Pre-service teachers should become metacognitively aware of their developing knowledge (Hughes & Scharber, 2008). Moreover, in order to help teachers set learning goals and make thoughtful decisions for technology integration, their metacognition should be activated (Doering et al., 2009). One of the principles of successful instruction of metacognition is to inform the learners about the benefits of applying metacognition to facilitate them for the initial extra effort. Therefore, PSTs' metacognition should be activated to think about their practices in technology integration. Moreover, they should be informed about the importance of teacher metacognition for improvement of their TPACK for effective SSI teaching, so that they can be facilitated to involve in preactive, interactive and postactive thinking processes.

> Design Principle 12 (DP12): PSTs' effective SSI teaching practices with technology can be developed by engaging them in design process.

Research showed the potential of learning technology by design approach on TPACK development (Hu & Fyfe, 2010) (See 2.2.2.2. Learning by design approach). Since PSTs do not have much experience in technology integration, planning and preparation for technology-integrated lessons was indispensable. Moreover, engaging pre-service teachers in the preparation of technology-enhanced instructional materials was also found important in many studies. Therefore, preparing instructional materials and lesson plans was found as a major theme by Tondeur et al. (2012). Thus, PSTs should be facilitated to design their instruction and instructional materials, and share these with their peers.

CHAPTER 3

METHODOLOGY

3.1. The Research Paradigm

In a research study, the researcher should clearly explain what methodologies and methods were employed and also justify the choice and use of these (Crotty, 1998). To do so, Crotty (1998) suggested considering different elements, including theoretical foundations, methodological approach and methods, to ensure the soundness of the research. Figure 5 summarizes the elements of this study. These elements are related to each other rather than being side by side as comparable perspectives (Crotty, 1998). Therefore, the meanings of each element and the relationship with other elements were explained in detail.

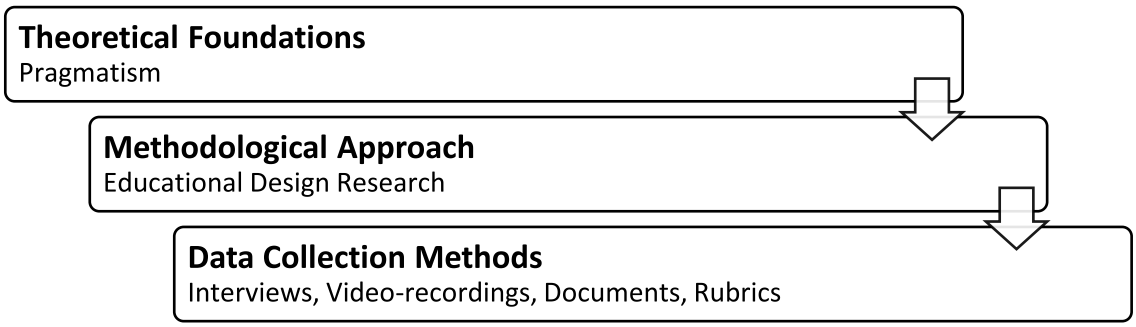

Figure 5. Elements informing this study

Pragmatism can be used as a philosophical approach in social research regardless of the method of the study (Morgan, 2014). It differs from the other philosophy of knowledge approaches (Guba; 1990; Guba & Lincoln, 2005), which view social research in terms of epistemology, ontology and methodology. Pragmatic philosophical approach redirects the researchers' attention to the methodological concerns rather than metaphysical concerns (Morgan, 2007). Therefore, the researcher who consider pragmatism's philosophical foundations emphasize *why to* aspect of research and ask the question “What difference does it makes to do our research one way rather than another?” (Morgan, 2014, p 1046).

For Deweyean transactional approach to pragmatism, reality is only *experienced* through organism-environment interaction (Biesta & Burbules, 2003). Biesta and Burbules (2003) summarized Dewey’s emphasis on action in knowledge construction as follows:

> We do something (and Dewey emphasized that we are always doing something, and cannot not do something) that affects our environment, we undergo the consequences of our doings, and try to adjust ourselves accordingly-and this cycle repeats itself. In the act of knowing-and hence in research-both the knower and what is to be known are changed by the transaction between them. (p.12)

This continuous cycle does not necessarily mean trial and error in gaining knowledge. By *thinking* the *possible* lines of action, the knowers, or researchers, make their responses more precise or more *intelligent* (Biesta & Burbules, 2003). The pragmatist school of thought that Dewey brought to research has some consequences on the educational inquiry. It changed the comprehension of the association between knowledge and action. Knowledge offers us opportunities for refining and supporting problem solving. Moreover, pragmatism gives us chance to think differently about the relationship between theory and practice. Educational research and educational practice is inseparable that educational practice is the field of applying the findings of educational research (Biesta & Burbules, 2003). Consequently, Biesta and Burbules (2003) outlined the aim of educational research from a pragmatist perspective that:

> In some ways, the most important conclusion that follows from a pragmatist understanding of educational research is that educational research is not only about finding better, more sophisticated, more efficient, or effective means for achieving educational ends that are taken for granted, but that inquiry into these very aims, ends, and purposes of education should be an integral part of educational research. (p.109)

In line with this school of thought, educational design research was chosen to bridge the relevance gap between theory and practice (Design-Based Research Collective, 2003). Since educational researchers should conduct pragmatic experimentation, which focuses on the importance of experimenting with new ways contrary to controlled experiments in laboratory setting in order to produce more relevant and actionable knowledge (Sloane, 2006). Similar to pragmatist educational research aim, Cobb et al. (2003) stated the aim of educational design research as:

> Beyond just creating designs that are effective and that can sometimes be affected by “tinkering to perfection,” a design theory explains why designs work and suggests how they may be adapted to new circumstances. (p.9)

Educational inquiry has similar dichotomy of the view of research as either *rigorous* or *relevant* as the classical view of research in basic science and technological innovations (Stokes, 1997). In determining what works in education, there is a tendency to alienate researchers, who emphasize evidence-based practices supported by rigorous and internally valid research, from practitioners, who value relevant and externally valid practice-based evidences, (Smith, Schmidt, Edelen-Smith, & Cook, 2013). This cause producing effective practices that only work in ideal conditions, which includes extra financial support and highly trained interventionists, rather than producing effective practices that work in typical settings.

Stokes (1997) suggested a matrix view of pure and applied research to categorize the studies seeking for fundamental understanding and/or practical applications of research as it was illustrated in Figure 6. According to Stokes (1997), studies characterized as seeking basic scientific knowledge with reliable and rigorous practices were resembled to Bohr’s studies, because while seeking for basic knowledge about the structure of atoms, he did not concerned with practical application of it. The studies categorized on the reverse quadrant, contrarily, focus on solutions to practical problems. Thomas Edison, who created innovative technologies to solve the problems of the society, was a typical researcher who pursued this kind of studies and was not much interested in publishing his findings to inform the scientific communities. Bridging the gap between these two contrasting views, Stokes (1997) emphasized the importance of the studies resembling Pasteur’s studies. The purpose of the studies in this quadrant is to merge evidence-based practices with practice-based evidences by seeking fundamental knowledge within the context of solving real world problems.

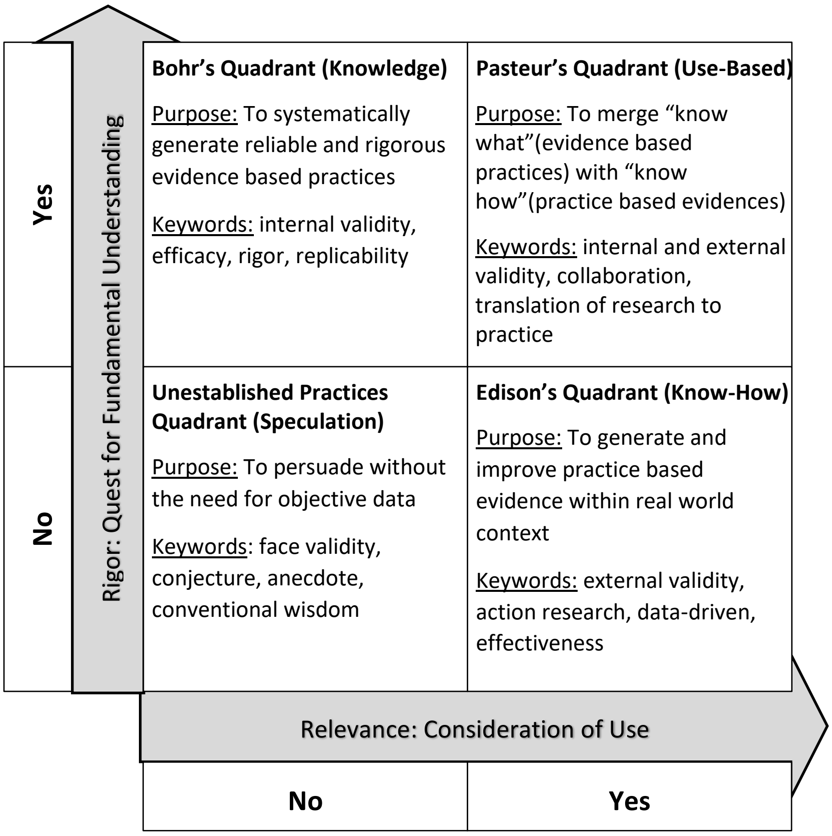

Figure 6. Quadrant model of scientific research (Smith et al., 2013, p.152)

In order to overcome the limitations of this dichotomy mentioned in basic and applied science, educational researchers introduced the strength of educational design research which is characterized as belonging to Pasteur's quadrant (McKenney, & Reeves, 2012; Reeves, Herrington, & Oliver, 2005; Smith et al., 2013). Through EDR, we also aimed to merge the evidence-based practices with practice-based evidences. By reviewing the related literature, we tried to find the appropriate ways to develop PSTs' effective SSI teaching practices with technology and to activate their metacognition about their SSI teaching. Therefore, we re-designed an undergraduate course based on the evidence-based practices. Moreover, by providing practice-based evidences we refined the course through iterative cycles of EDR. That is, it was aimed to merge know what (what constitutes PSTs' effective SSI teaching with technology) and know how (how PSTs' effective SSI teaching practices with technology can be developed by activating metacognition through educational design research).

3.2. Educational Design Research (EDR)

Since the landmark papers of Collins (1992) and Brown (1992), the researchers aiming to design educational products, processes, programs or policies gained a new insight. As Brown (1992) pointed out, EDR provides opportunity "to engineer innovative educational environments and simultaneously conduct experimental studies of those innovations" (p.141). This particular systematic methodology with the goal of both developing theory to guide implementation of future innovations and designing and implementing an innovation has been labelled differently. Among various names, design-based research (DBRC, 2003), development research (van den Akker, 1999), design experiments (Brown, 1992; Collins, 1992), formative research (Newman, 1990) and educational design research (McKenney & Reeves, 2012) were the most commonly used ones. Moreover, some researchers identified the design research as an emerging paradigm for educational inquiry (Design-Based Research Collective, 2003; Edelson, 2002), while others called it as a research methodology (Bell, 2004; Wang & Hannafin, 2005) or a research genre (McKenney & Reeves, 2012). McKenney and Reeves (2012) defined the educational design research as "a genre of research in which the iterative development of solutions to practical and complex educational problems also provides the context for empirical investigation, which yields theoretical understanding that can inform the work of others" (p.7). In this study, the term "educational design research" was used to refer the methodological approach of the study. Although design-based research is the most commonly used term, as McKenney and Reeves (2012) stated, incorporating *education* in the term would assure avoidance of confusion about the field of design research.

McKenney and Reeves (2012) identified two main orientations to educational design research according to the role of the designed intervention in the investigation, namely, design research conducted *through interventions* and *on interventions*. The intervention is viewed as a means in the former, while it is viewed as an end in the latter. Design research through interventions are more suitable for contributing to theoretical understanding of, for example, patterns of pedagogical content knowledge development of teachers. Design research on intervention more focus on the qualities and characteristics of the intervention and more suitable to contribute the theoretical understanding of curriculum, professional development program or instructional material development studies. Although design research can be conducted either through intervention or on intervention, design studies often reflect both orientations throughout the complete study (McKenney & Reeves, 2012). In this study, the intervention was both the means of inquiry and an object of study with varying focus in the different cycles.

As McKenney and Reeves (2012) stated "educational design research is a complex and multi-faceted endeavor" (p. 13). Although it has similar characteristics with other families of inquiry, there are unique features of educational design research mentioned in the literature. EDR characterized as being adaptive, interventionist, collaborative, flexible, utility-oriented, process-oriented, pragmatic, grounded, contextual, interactive, iterative, flexible, integrative, contextual, methodologically inclusive, multilevel, theoretical, and transformative (Cobb et al., 2003; McKenney& Reeves, 2012; Plomp, 2013; van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). Here, the most commonly mentioned characteristics of the EDR were explained in detail with reference to the characteristics of this study.

3.3.1. Pragmatic

As emphasized in many studies, educational design research is pragmatic in different ways (Andersun & Shattuck, 2012; Bannan-Ritland & Baek, 2008; Barab & Squire, 2004; Middleton, Gorard, Taylor, & Bannan-Ritland, 2008; McKenney & Reeves, 2014; Wang & Hannafin, 2005). The choice of methods and the focus on the authentic issues as the main research topic resonate with pragmatic research approach of Pasteur (Andersun & Shattuck, 2012; Reeves, 2014). Educational design research aims to develop usable knowledge that serves local practice (Barab & Squire, 2004; McKenney & Reeves, 2014). In this study, design principles were revealed based on the literature to determine the evidence-based best practices to inform the design of this study. Then with the practice-based evidences, these principles were refined to inform further design studies.

To make it more manageable, researchers suggest to select a suitable methodological approach, as well as to consider resources, partners, and other factors pragmatically (Ejersbo, Engelhardt, Frolunde, Hanghoj, Magnussen, & Misfeldt, 2008). This study was also pragmatic that the main concern of the study was to re-design an undergraduate course that aim to develop PSTs' effective SSI teaching practices with by activating metacognition. The course was aimed to provide a practical solution to the need of developing PSTs' knowledge for effective SSI teaching through technology and the selection of research methods in reaching this purpose was also pragmatic. The course was re-designed considering the available time for course hours, and resources that can be used.

3.3.2. Collaborative

EDR requires the contribution of different stakeholders who are related to the problem being studied. Different collaborators (usually researchers, teachers, and students) provide input for the design with varying responsibilities in design process from co-designers to users of the design (Hjalmarson & Lesh, 2008). Researchers and different collaborators of the study contribute each other's learning while adapting the interventions to reach the goals concurrently (Zawojewski, Chamberlin, Hjalmarson, & Lewis, 2008). The collaborators of the design process differ according to the aim and scope of the study. For example, researchers, facilitators, and teachers can be the possible collaborators of a design research aiming professional development for teacher (Zawojewski et al., 2008). In a large scale such as the study aiming to develop theory related to improving the quality of classroom instruction and student learning at the system level, more complex collaboration with different stakeholders including teachers, coaches, instructional leaders, and district leaders is needed (Cobb, Jackson, Smith, Sorum, & Henrick, 2013).

This study was also the resultant of the collaboration of different partners. First, I was in close collaboration with the participants of the study, who were the pre-service science teachers enrolled in the re-designed course, throughout the whole semester. With the role of teaching assistant of the course, I always guided them while designing and implementing their lesson plans. Moreover, they always provided me information necessary to revise and refine the re-designed undergraduate course through reflection papers and interviews as well as through informal discussions.

Another close collaboration was between my advisor, who was the instructor of the course, and me. We prepared additional presentations about TPACK and metacognition to be included into the already existing lecture notes about SSI to be presented in the comprehension phase of the course. We came together after the class meetings to discuss the difficulties that PST faced with during the learning activities. In order to increase the effectiveness of learning activities in developing PSTs' TPACK understanding and activating metacognition, supplementary reading materials was decided to be included in the course pack, if necessary. Based on the quick analysis of their class discussions, their misunderstanding about SSI, TPACK or metacognition were determined and necessary discussion questions were decided to be directed to them in following weeks to clarify the misunderstood points. Moreover, before and after each implementation, we consulted to the thesis committee members for their advices. We discussed the findings and suggestions for revisions about the course design in regular thesis committee meetings.

There was an instructor, my advisor, and two teaching assistant of the course including me and another PhD candidate in science education field. The specialization of other teaching assistant is metacognition, environmental education and socio-scientific issues. She also provided guidance to PSTs in designing and implementing their lessons about socio-scientific issues. Moreover, we frequently came together to evaluate the effectiveness of the learning activities and the overall design of the course.

Another contribution for the study was done by the science teachers working in the foundation school of the university. The science group leader of the school committed science teachers who are the active teachers in terms of technology integration. The committed teacher and the group leader worked together to prepare a presentation exemplifying their technology integration practices as individual teachers and as institution. The committed teachers (different teacher for each implementation) came to class and explained the technology integration policies and practices of their institution.

3.3.3. Theoretically oriented

In order to link the educational research and educational practice to enhance the meaningful impact of research on practice, EDR offers promising solutions. First, as it was described above, it requires practitioners and researchers to collaborate in determining the educational problem to be studied. The second way of enhancing the alignment between educational research and educational practice is putting emphasis on the role of theory in shaping not only the research, but also the design on a solution to the real educational problem (Reeves, McKenney, & Herrington, 2011; McKenney & Reeves, 2012). Although theory seems to be an afterthought in other educational research approaches, in EDR, it plays a central role (Reeves et al., 2011). Social constructivism was considered as the learning and teaching theory of this study. In line with the social constructivist point of view, theories about teacher knowledge required for SSI teaching, technology integration and teacher metacognition shaped this study. Moreover, theories about instructional design in developing TPACK informed the design of the course.

There is a two-way interaction between theory and experiment, namely prospective and reflective. "Theory prospectively informs the design for the design experiment, and is further developed in the retrospective reflection on deviances between the expected and the observed teaching and learning processes" (Prediger, Gravemeijer, & Confrey, 2015, p. 879). The goal of EDR is to not only refine the solutions but also generate theories that do real work (Cobb et al., 2003). Theory generation means both developing and refining theories rather than testing as in experimental studies (Prediger et al., 2015). The theories developed through EDR are pragmatic and humble; "humble in the sense of being concerned with topic-specific learning processes and pragmatic in that they effectively inform prospective design" (Prediger et al., 2015, p.879).

The theory developed through EDR can serve various purposes, which are describing, explaining, predicting, and prescribing. Moreover, EDR can lead to educational theories in different levels, which are local theories, middle-range theories and high-level theories (McKenney & Reeves, 2012). From a learning processes perspective, Pregider et al. (2015) labelled the different levels of theories as orienting frameworks or background theories, domain-specific instruction theories as frameworks for action, and local instructional theories/humble theories/hypothetical learning trajectories, from most general level to the most specific, respectively. Mostly, theorizing process occur on the level of local instructional theories. The design studies start with hypothesized local instructional theory, however, the aim is not to accept or reject the theoretical elements rather to revise, improve or refine them, contrary to the quasi-experimental research (Prediger et al., 2015).

Although not all EDR studies are expected to produce theories for all purposes at all levels, explanatory and predictive theories is needed to design interventions, and prescriptive/normative theories are needed to refine the interventions (McKenney & Reeves, 2012). “Design principles” is the term used to represent the type of theoretical understanding with prescriptive purpose. Since one of the yield of EDR studies is to produce fruitful design principles to be guide for further design attempts, producing design principle with prescriptive purpose make the EDR more powerful in terms of linking theory and practice.

This study was informed by broad literature on teacher knowledge required for SSI teaching and technology integration. The literature on what constitutes the TPACK of pre-service teachers and the ways to develop that knowledge was reviewed thoroughly. The re-designed course was grounded on the empirical research in this area. Moreover, the results of this study aimed to contribute to theoretical understanding about developing PSTs’ effective SSI teaching practice with technology and promoting metacognition about teaching SSI with technology. Besides, the principles emerged as a result of prospective and retrospective analysis aims to guide the similar studies in this field.

3.3.4. Interventionist

Educational design research is “test-beds for innovation” with an aim of improving education (Cobb et al., 2003). EDR tries to effect practice in a positive way by designing and using solutions to real world problems; therefore, the main purpose of the design teams is to “engage in the creative activity of developing solutions informed by existing scientific knowledge, empirical testing, and the craft wisdom of project participants” (McKenney & Reeves, 2012, p.14). In this study, intervention refers to the re-designed undergraduate course.

3.3.5. Iterative

There is not a straightforward roadmap for design-based studies to be followed to reach the conclusion. Rather, design research aligns with engineering in terms of heavy use of iterative design-and-test cycle to meet the demands in most effective way (Middleton et al., 2008). Iteration is the natural and necessary part of the design studies in education and engineering (Hjalmarson & Lesh, 2008). In addition to the first two phases of “classic” research model that are identifying the research problem and designing a testable solution, design studies includes feasibility, prototyping and field-testing phases to increase the likely effectiveness of the intervention (Middleton et al., 2008).

Educational design research includes iterative cycles of analysis, design and development, evaluation and revisions, which provide information to the designer leading to better design (DBRC, 2003). Iterations provide information to improve not only the design at hand, but also the context and system where design is used (Hjalmarson & Lesh, 2008). Gravemeijer and Cobb (2006) conceptualized this iterative nature of their design experiments as macrocycles and daily microcycles, which includes the revisions in light of retrospective analysis. McKenney and van den Akker (2005) illustrated the eight cycles of their study within the phases of their design study by showing the proportional length of the cycles.

The scope and time interval of the cycles can range based on the type of design research. Moreover, each stage of the design research may include one or more cycles and cycles may have more than one iterations (Plomp, 2013). In order to conduct rigorous research, each cycles should begin with research questions showing the quality criteria emphasized in the cycle (Plomp, 2013). In this respect, the design research model developed by Dowse and Howie (2013) was adapted to this study (see Figure 2) to operationalize the cycles within the phases of the study by applying the quality criteria for interventions suggested by Nieveen and Folmer (2013). Therefore, within the three phases, this study included eight cycles with their own research questions emphasizing different quality criteria.

3.3. Participants of the Study

Participants were 80 pre-service science teachers who were enrolled in a one-semester undergraduate course in the teacher education program of one of the public universities in Ankara, Turkey. The course is offered as a must course in elementary science education program. Therefore, the participants were supposed to take this course to fulfill the course requirements of the program. In the first implementation 36 (4 male, 32 female) pre-service science teachers and in the second implementation 44 (6 male, 38 female) pre-service science teachers enrolled in the course. All of the PSTs were asked to participate to the study voluntarily. Each volunteered participants signed a consent form. Pseudonyms (Table 5) were used when referring to a specific participant in data collection and analysis procedures to ensure the confidentiality.

Participants were asked to work in groups in each implementation. PSTs prepared and enacted their lesson plans in these groups. Since gaining experience in preparing lesson plan and enacting the plan was considered as necessary for development of effective SSI teaching practices with technology, each PSTs were tried to be given chance to practice these. To be able to provide chance to each PSTs enact their lesson plans in class hours, they were asked to work in groups for feasibility concerns. Table 5 includes the pseudonyms for the group names and the group members. The pseudonyms defined in Table 5 were used in the quotations throughout the dissertation.

Table 5
Pseudonyms for the Group Names and the Group Members

First Implementation (FI)				Second Implementation (SI)			
Group Code	Participant Code	Group Code	Participant Code	Group Code	Participant Code	Group Code	Participant Code
FI_G1	FI_G1_SKO FI_G1_MK FI_G1_BK FI_G1_AA FI_G1_AG	FI_G5	FI_G5_SA FI_G5_RD FI_G5_DC FI_G5_AKA	SI_G1	SI_G1_EC SI_G1_DCI SI_G1_AO SI_G1_FS SI_G1_CU	SI_G5	SI_G5_BÇ SI_G5_RK SI_G5_NFO SI_G5_BKŞ SI_G5_HY
FI_G2	FI_G2_AK FI_G2_SK FI_G2_SUA FI_G2_BU FI_G2_MBT	FI_G6	FI_G6_RO FI_G6_SET FI_G6_BY FI_G6_BE	SI_G2	SI_G2_ZB SI_G2_DB SI_G2_KÇ SI_G2_EO SI_G2_ET	SI_G6	SI_G6_DC SI_G6_MKA SI_G6_MO SI_G6_MCO SI_G6_DT SI_G6_OU
FI_G3	FI_G3_CAD FI_G3_MSY FI_G3_CY FI_G3_GI FI_G3_MO	FI_G7	FI_G7_CA FI_G7_FB FI_G7_BB FI_G7_OK FI_G7_DB	SI_G3	SI_G3_BB SI_G3_EÇE SI_G3_AFE SI_G3_FK SI_G3_SK	SI_G7	SI_G7_RA SI_G7_MK SI_G7_HK SI_G7_CO SI_G7_IT SI_G7_AY
FI_G4	FI_G4_BKI FI_G4_EA FI_G4_EG FI_G4_SNA	FI_G8	FI_G8_ME FI_G8_CAY FI_G8_EY FI_G8_AD	SI_G4	SI_G4_EAL SI_G4_RÇ SI_G4_KD SI_G4_FO SI_G4_EY	SI_G8	SI_G8_EAC SI_G8_EAR SI_G8_HC SI_G8_GGO SI_G8_GGU SI_G8_MM SI_G8_AS

Note. An example nomenclature for the pseudonyms of group members was given below.
FI_G1_SKO = Implementation time_Group number_participant code

PSTs were asked to give some information about their technology usage level and frequencies before starting to the implementation. The participants of the different implementation had similar demographic characteristics in terms of technology access and usage (Table 6). Except one PST from the first implementation, all PSTs had their own personal computer. In both implementations, majority of them stated that their computer usage level was good. Moreover, majority of PSTs from both implementations declared that they were using computer about 1-3 hours in a day. Furthermore, majority of the PSTs in each implementation said that they accessed internet from their home.

Table 6
Demographics of the Participants

Variable	First Implementation		Second Implementation	
	N	Percent	N	Percent
Gender				
Male	4	11.1	6	13.64
Female	32	88.9	38	86.36
Computer possession				
Yes	33	91.7	36	83.7
No	1	2.8	0	16.3
Computer usage level				
Beginning	0	0	0	0
Medium	7	19.4	10	23.3
Good	21	58.3	22	51.2
Advanced	6	16.7	4	9.3
Computer usage frequency				
1-3 hour in a week	2	5.6	1	2.3
Less than 1 hour in a day	4	11.1	4	9.3
1-3 hour in a day	21	58.3	23	53.5
More than 4 hours in a day	7	19.4	8	18.6
Internet access site				
Home	22	61.1	24	55.8
Dormitory	10	27.8	6	14.0
University	2	5.6	5	11.6
Others	0	0	1	2.3

Besides information about PSTs' general technology possession and usage level, they were asked about the frequency of their usage of some most commonly used technologies in daily life and education (Table 7).

PSTs' technology usage frequencies showed similarity. Most frequently used technology was e-mail for PSTs in both implementations that 47.2% of PSTs in FI and 41.9% of PSTs in SI stated that they always use e-mail. On the other hand, podcasts, and simulation software were among the least frequently used technologies. For podcasts, 8.3% of the PSTs in the first implementation even did not know anything, while 44.4% of them never use it and 27.8% of them seldom use. Similarly, 16% of the PSTs in the second implementation did not know anything about podcast, 32.6% of them never use, and 18.6% of them seldom use it. For simulation software, 5.6% of the PSTs in the first implementation did not know anything, while 38.9% of them never used and 33.3% of them seldom used it. In the second implementation, 41.9% of PSTs never used and 34.9% of them seldom used simulation software.

Table 7
Technology Usage Frequencies

Technology	First Implementation						Second Implementation					
	0 (%)	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	0 (%)	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)
Blog (i.e. Wordpress, blogger)	0	8.3	44.4	25.0	11.1	5.6	0	2.3	48.8	30.2	2.3	0
Bookmarking (i.e. delicious)	2.8	30.6	25.0	11.1	16.7	8.3	7.0	27.9	16.3	11.6	18.6	2.3
Photo sharing (i.e. Flickr)	2.8	2.8	22.2	33.3	25.0	8.3	0	11.6	9.3	30.2	16.3	14.0
Video sharing (i.e. Youtube)	0	19.4	33.3	16.7	16.7	8.3	0	16.3	25.6	18.6	18.6	4.7
Status updating (i.e. Twitter)	0	22.2	19.4	16.7	30.6	5.6	0	27.9	18.6	18.6	16.3	2.3
File sharing (i.e. GoogleDocs)	2.8	25.0	16.7	22.2	16.7	8.3	4.7	7.0	32.6	20.9	11.6	7.0
Social networking (i.e. Facebook)	0	2.8	5.6	16.7	30.6	38.9	0	2.3	2.3	23.3	39.5	16.3
Wiki (i.e. Wikipedis)	13.9	22.2	13.9	19.4	16.7	8.3	2.3	9.3	2.3	34.9	25.6	7.0
Podcast	8.3	44.4	27.8	8.3	0	5.6	16.3	32.6	18.6	11.6	0	2.3
e-mail	0	0	0	13.9	33.3	47.2	0	0	2.3	4.7	34.9	41.9
Instant messaging (i.e. Google talk)	11.1	13.9	2.8	11.1	19.4	36.1	0	14.0	9.3	9.3	23.3	27.9
Learning management system (i.e.Moodle)	22.2	30.6	19.4	11.1	5.6	5.6	7.0	32.6	27.9	7.0	9.3	0
Published materials (i.e. books)	0	0	5.6	25.0	38.9	25.0	0	0	2.3	23.3	23.3	34.9
Educational softwares (i.e. Vitamin)	0	13.9	44.4	27.8	2.8	5.6	0	18.6	32.6	23.3	4.7	4.7
Spreadsheets (i.e. MS Excel)	0	2.8	30.6	33.3	11.1	16.7	0	2.3	11.6	39.5	23.3	7.0
Word processors (i.e. MS Word)	2.8	5.6	5.6	16.7	30.6	33.3	0	9.3	7.0	23.3	30.2	14.0
Presentation tools (i.e. Powerpoint)	0	0	2.8	16.7	50.0	25.0	0	0	2.3	27.9	39.5	11.6
Image editing (i.e. Paint)	0	5.6	11.1	36.1	25.0	16.7	0	0	11.6	44.2	14.0	14.0
Animation preparation (i.e. Adobe Flash)	0	33.3	36.1	16.7	8.3	0	0	25.6	32.6	20.9	2.3	2.3
Simulation (i.e. Experiment simulations)	5.6	38.9	33.3	16.7	0	0	0	41.9	34.9	7.0	0	0

Note. 0 = Don't know 1 = never, 2 = seldom, 3 = sometimes, 4 = frequently, 5 = always

The re-designed course was managed with the university's learning management system (LMS). All of the assignments were assigned and uploaded through this system. Videos of teaching performances were shared and commented with the help of this system. Grades were announced on this system. That is, PSTs were supposed to follow the weekly course flow on the LMS actively. However, in the first implementation 22.2% of the PSTs did not know anything about LMS, and 30.6% of them never used and 19.4% of them seldom used LMS. Similarly, in the second implementation, 7.0% of the PSTs did not know LMS and 32.6 % of them never used and 27.9% of them seldom used LMS. LMS was started to be used in the university starting from September 2014. Therefore, PSTs participated to the first implementation did not have any previous experience with LMS. Similarly, the second implementation was conducted in 2015-fall semester. Therefore, LMS was relatively new for also PSTs in second implementation. To help PSTs to take the most advantage of LMS, the LMS was introduced to the PSTs in the first week of the course. They were informed about where to reach the resources, how to attend the activities designed in the LMS, and how to upload assignments, etc.

One of the important technologies to be considered was Wiki. PSTs were expected to use Wikis in the re-designed course. PSTs prepared their group lesson plans by using the Wiki pages created for their own group embedded in LMS. However, the percentage of PSTs using Wikis frequently or always was about 25-30%. There were PSTs who even do not know what Wiki is in both implementations (13.9% in FI and 2.3% in SI). Since PSTs were expected to use Wiki pages created for their group lesson plans, they were again informed about how to prepare their lesson plans through these Wiki pages.

Other important technologies to be considered were blogs, presentation tools and file sharing tools. Most of the PSTs in both implementations (44.4% in FI and 48.8% in SI) stated that they seldom used blogs. There were not any PSTs who stated that they did not know about blogs, because they learned how to prepare blogs in the Instructional Technology and Material Development course they took in the fifth semester. On the other hand, majority of the PSTs in both implementations (50.0 in FI and 39.9 in SI) declared that they frequently used presentation tools. The frequency of file sharing tools like GoogleDocs or Dropbox was varying in both implementations. Some PSTs never used these tools (25.0% in FI and 7.0% in SI) or even were not aware of these tools (2.8% in FI and 4.7% in SI). However, there were also some PSTs who stated that they used file sharing tools frequently (16.7% in FI and 11.6% in SI) or always (8.3% in FI and 7.0% in SI). The percentages of PSTs in terms of file sharing tools usage frequency also showed similarity in both implementations. In order to make them aware of these tools they were provided a toolbox. The toolbox included some example applications or websites that can be used for file sharing.

All of the PSTs had some basic skills to use technology and had knowledge about educational technologies, because all of them took the course named "Computer Application in Education" given in the second semester which aim to teach the basic concepts and skills about computer. Furthermore, about technology use, they also had knowledge about the characteristics of various instructional technologies, the place and use of technologies in instructional process, development of teaching materials through instructional technologies (worksheets, transparencies, slides, videotapes, computer-based course materials, etc.), and assessment of the qualities of various teaching materials thanks to the course they took in the fifth semester with the name of "Instructional Technology and Material Development" as stated in the course description.

All of the participants also took method courses. They learned the concepts of science process skills, scientific inquiry, nature of science, conceptual understanding, graphical organizers, such as concept map, V-diagram, KWHL, and roundhouse, and teaching strategies and their applications in elementary science education as stated in the course description of "Methods of Teaching Science I" course given in the fifth semester. Moreover, PSTs learned about teaching strategies for elementary science including project-based learning, problem-based learning, peer instruction, role playing, teaching with analogy, laboratory and field work and use of technology in science teaching; and designing and implementing classroom lesson plans, and microteaching in the "Methods of Teaching Science II" course given in the sixth semester. Therefore, PSTs learned different instructional strategies that can be used in teaching SSI.

Besides technology and method course, PSTs also took different science courses before taking the re-designed course. While designing and implementing classroom lesson plans about socio-scientific issues PSTs may need scientific knowledge from the field of physics, chemistry, general biology, molecular biology, physiology or other similar scientific fields. PSTs came to the class with necessary background scientific knowledge that they gathered throughout the science courses they took in previous semesters to effectively learn and teach SSI topics in this course.

3.4. Data Collection Methods

In this study, the main purpose was to re-design a course which focused on developing PSTs' effective SSI teaching practices with technology. Through re-designing, metacognition of PSTs was also tried to be addressed. To evaluate the effectiveness of the course in reaching the aim of the study, formative and summative evaluations were done by using various data collection tools. These data collection tools and their purposes were listed in Table 8.

Table 8
Data Collection Methods

Data collection tool	Purpose of the tool	Time of the data collection
Group lesson plans (GLP)	To investigate the knowledge of PSTs as groups about technology-enhanced SSI teaching	Throughout the semester in both implementation
Individual lesson plans (ILP)	To investigate the development in PSTs' knowledge in technology-enhanced SSI teaching	At the end of the semester as a final project in both implementation
Video-Tape Recordings	To record PSTs' SSI teaching experiences to show PSTs for video-stimulated recall interviews, video comments and reflection paper II To evaluate their teaching performances in terms of the effectiveness of SSI teaching with technology	In the first implementation, about one hour for each group In the second implementation; about one and a half hour for each group (a half hour for initiation activities for teaching and an hour for teaching performances in the consecutive week)

Table 8 (continued)
Data Collection Methods

Data collection tool	Purpose of the tool	Time of the data collection
Reflection Paper-1 (RP_1)	To investigate PSTs' metacognition underlying instructional practice	At the beginning of the first implementation A revised version of it at the beginning of the second implementation
Reflection Paper-2 (RP_2)	To investigate PSTs' metacognition underlying instructional practice (After watching the video-recordings of their teaching performances PSTs monitored and evaluated their own performance by answering the questions provided in the assignment)	In the first implementation, groups submitted their paper due the next week of their teaching performance In the second implementation, PSTs submitted a revised and simplified version of the assignment due the next week of their groups' second teaching performance
Reflection Paper-3 (RP_3)	To investigate PSTs' metacognition in postactive stage To investigate PSTs' thoughts about effectiveness of the re-designed course	In the first implementation, each PST submitted their paper due the final date
Post-teaching structured interviews (PTSI)	To investigate metacognition underlying instructional practice	In the second implementation, 20 volunteer participants were interviewed after their second teaching performances and before the VSRIs
Video-Stimulated Recall Interviews (VSRI)	To investigate PSTs' interactive metacognition underlying instructional practice	In the first implementation, through the end of the semester In the second implementation, within at most 48 hours of their groups' second teaching performances

3.4.1. Lesson plans

In order to guide pre-service teachers in designing technology-integrated SSI teaching lessons, a TPACK lesson plan template was prepared in this study (see Appendix A). The lesson plan template developed in the scope of a TÜBİTAK project named Ortaöğretim Fizik Öğretim Programı ile Bütünleşik, Etkileşimli Bilgisayar Animasyon, Simülasyon ve Öğrenme Ortamları İçeren Modüller Hazırlanarak, Hizmet-İçi Eğitimler Yoluyla Yaygınlaştırılıp Eğitim Sürecine Uyumunun Sağlanması ve Öğretmenlerin Teknolojik Pedagojik Alan Bilgilerinin Geliştirilmesi [Preparing Modules Including Interactive Animations, Simulations and Learning

Environment Closely Aligned with Secondary Physics Curriculum Outcomes, Making the Adaptation to Educational Processes by Disseminating it through In-service Trainings and Developing Teachers' Technological Pedagogical Content Knowledge], in which the researcher worked as a scholar, guided the lesson plan template preparation. Moreover, the studies exploring the planning of technology-integrated lessons were utilized to create the outline of the lesson plan template (Canbazoğlu Bilici, 2012; Haşlaman, Kuşkaya Mumcu, & Usluel, 2007; ISTE, 2012; Wang & Woo, 2007). By examining the lesson plan templates of these studies and the theoretical framework of the study defined by Niess (2005) the elements that should be included in the template were decided. After determining the outline of the template, sample prompts for thinking and preparing for effective technology-enhanced lessons provided in Niess (2008) were adapted to the template used in this study.

PSTs prepared their first lesson plans as groups using the TPACK lesson plan template in the LMS of the university. Wikis were considered as important collaborative learning tools for developing science teachers' knowledge and they have great potential to transform learning by scaffolding social contructivism (Chen, Jang, & Chen, 2015). Therefore, to give PSTs opportunity to work and write collaboratively based on social constructivist perspective, a wiki page was embedded in LMS for each group (DP4, DP6). Everyone had access only to their groups' lesson plan Wiki page. Lesson plan template was uploaded to the wiki pages by the researchers and PSTs filled the necessary part of the plan collaboratively. Students were expected to contribute to lesson plan equally and their contributions to the plans were examined by looking Wiki history. The interface of groups' Wiki pages was illustrated in Figure 7.

Every group is expected to select a science-technology-society related topic (it should be a socioscientific issue) from Turkish science curriculum. Then, you will write a technology integrated lesson plan as a group. You will expected to prepare your lesson plan collaboratively on this wiki file created for your group. You can prepare your lesson plan by editing the lesson plan template provided you in this wiki page. You are expected to conduct your discussions through the comments page.

As it is seen in Figure 7, Wiki pages included different properties. By using the editing property, PSTs filled the empty lesson plan template. While preparing their lesson plans, PSTs' were expected to communicate with their group members through comment page of their wiki pages. Moreover, teaching assistants of the course also stimulated the group members to progress by writing comments about the written parts of the plans (DP6). PSTs also were free to write any concerns about their plans to be answered by the course assistants. Therefore, the comment properties of the wikis served as a medium for online discussion about their planning process.

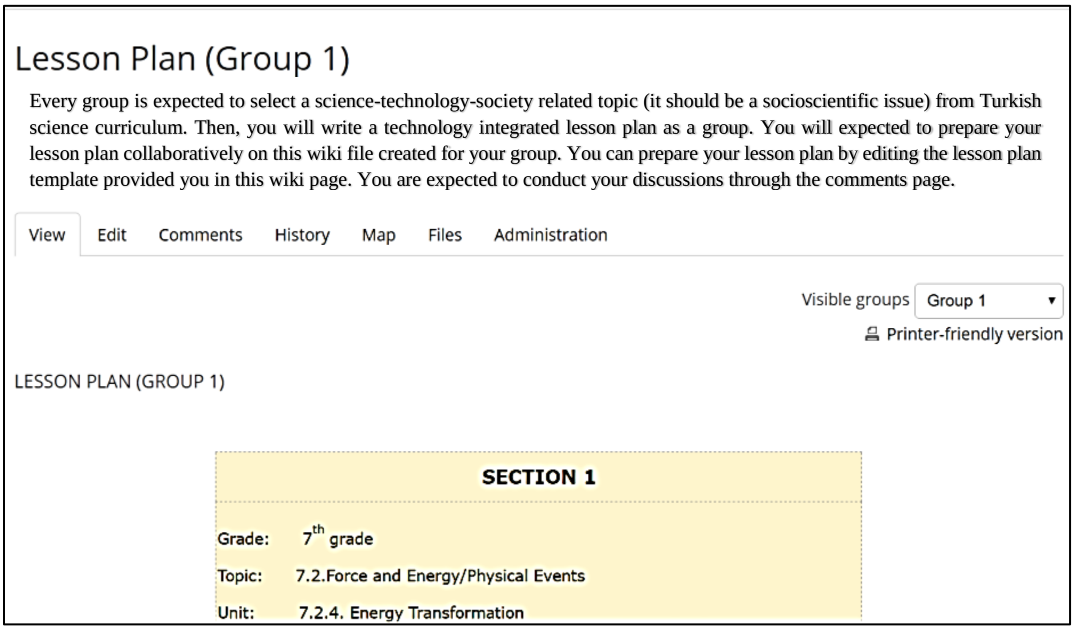

Figure 7. Interface of group lesson plan wiki pages

At the end of the semester each participants were expected to prepare a new lesson plan about any SSI topic individually. The participants used the same lesson plan template with the same prompting questions embedded in it. They prepared their individual lesson plans as word documents and uploaded their plans to the LMS with additional files (if there is any).

3.4.2. Video-tape recordings

PSTs performed their SSI teaching practices based on the lesson plans they prepared as groups. Their teaching performances were recorded from both sides so that front and back view of the class were captured. Back views of the classroom showing what teachers were doing on the board clearly were used for reflections and video-stimulated recall interviews. Front views of the classroom were used as complementary data in analysis to better see what students did in activities.

In the first implementation, PSTs' teaching performances lasted one lesson hour. Two groups performed their teaching in each week. There were totally 8 groups, therefore, teaching performances continued for 4 weeks. Until the end of the semester, about 8 hour teaching performances were recorded totally.

In the second implementation, a change in the duration of the teaching performances was decided to be done. It was realized that PSTs' got difficulty in completing their teaching activities in one hour. Therefore, an additional half hour was devoted to each group to conduct preliminary activities before covering their SSI topic. In the first week, they introduced their socioscientific issue to the classroom to eliminate any possible background knowledge deficiency. Moreover, they explained which aspects of the SSI topic they expected students to focus on and clarified the arguments from different aspects. Then, in the consecutive week, they implemented their teaching activities in one hour to cover their SSI topic. Again, there were 8 groups and until the end of the semester, about 4 hours for initiations of teaching and 8 hours for teaching performances were recorded.

3.4.3. Video-stimulated recall interviews

Video-stimulated recall interviews (VSRI) is a research method through which researcher presents authentic stimuli and cues to the interviewees to reveal their thoughts about the original situation (Vesterinen, Toom, & Patrikainen, 2010). Bloom (1953), who was the first to use this method, defined the method as follows:

> The basic idea underlying the method of stimulated recall is that the subject may be enable to relive an original situation with vividness and accuracy if he is presented with a large number of the cues or stimuli which occurred during the original situation. (p.161)

VSRI was used in this study to invite PSTs to reflect on their decision-making processes during their teaching performances. As the stimuli, video-recordings of PSTs' teaching performances were shown to the participants. If each member of the groups volunteered to participate, participants were interviewed as groups. There were 6 groups from the first implementation and 5 groups from the second implementation volunteered to participate.

There were differences in the way of conducting interviews in two implementations. In the first implementation, groups were interviewed toward the end of the semester. Before coming to the interview, participants were asked to watch their teaching performance videos at least once. Then, video recordings of their performances were watched together through a laptop. At some predetermined points, video was paused by the researcher and some prompting questions were asked to encourage them to talk about their thoughts of that time. Sometimes, PSTs wanted from researcher to pause the video and they talked about their thoughts. While interviewing and transcribing the audio recordings of the interviews, it was realized that there was a major problem about remembering the situations. Some participants had difficulty in remembering their exact thoughts. This leaded them to talk about their current thoughts instead of their thoughts in the original situation. Therefore, more than one-week time lapse between the event (teaching performance) and the VRSI was decided to be interfering factor in obtaining PSTs' concurrent thinking during the event and this time lapse was decided to be shorten in the second implementation.

In the second implementation, interviews were arranged in a way that the time lapse between the second teaching performance and the VSRI was not more than 48 hours. This immediacy is an important characteristic of the VSRI techniques because any time lapse may interfere with a participant's recall of thinking during the event (McTavish, 2008) as it was observed in the first implementation. Another important change in the implementation of the techniques was that the control of the video-recordings left to the interviewees. The interviews were conducted in a seminar room. The video recording of the teaching performance was projected on the wall. A remote controller was put at the center of the meeting desk. The participants were given the following direction:

What we're going to do now is to watch your video. I am interested in what you were thinking at the time you were teaching. I can see what you were doing by looking at the video, but I don't know what you were thinking. So what I'd like you to do is tell me what you were thinking, what was in your mind at that time while you were implementing your instructional activities. I can give one example about my thinking on my sample teaching performance. I'm going to put the remote control on the table here and you can pause, speed up or slow down the video any time that you want. So if you want to tell me something about what you were thinking, you can push pause. If I have a question about what you were thinking, then I will push pause and ask you to talk about that part of the video.

Before the interviews, specific points of times were determined that PSTs seem to make a decision. If participants did not stop the video at those points, interviewer stopped the video and asked such general questions:

What were you thinking here/at this point/right then?, What were you thinking when you decided to do this?, Why did you decide to do that?, I see you're laughing/looking confused/saying something there, what were you thinking then?

If PSTs responded to the questions that they do not remember, the interviewer did not ask any following questions. Because the answers that were not given immediately increases the possibility that the answers will not represent their thoughts at the time they were teaching but their current thought or some other memory or perception (McTavish, 2008).

3.4.4. Reflection papers

There were three different reflection papers asked from PSTs to write (see Appendix C). The main purposes of reflection papers were to reveal PSTs' metacognition and provide feedback about the re-designed course. The first reflection paper was given to PSTs as assignment after the comprehension stage of the lesson, which includes the introductory lectures. PSTs were supposed to answer the prompting questions while organizing their reflection paper. The questions included both cognitive and metacognitive prompts. In this paper, PSTs' mainly were asked to rate their own TPACK and change in their TPACK conceptions for effective SSI teaching through the activities held in the comprehension phase of the course.

PSTs wrote their second reflection paper after their teaching performances. After teaching performance of their own group, each PST wrote a reflection paper individually to evaluate their teaching. In this reflection paper, they were expected to evaluate their teaching by answering the questions provided them. In the first implementation, two types of reflection paper-2 were planned to be used. We planned that each PST would write one reflection for their own teaching performance. At the same time, they were expected to write reflection for other groups' performances. That is, they were expected to write one reflection as performers and seven reflections as observers. However, due to the detailed prompting questions embedded in the reflection paper to evaluate the effectiveness of their SSI teaching with technology, PSTs complained that they had difficulty in completing the assignments of the course. They requested to reduce the requirements of the course. Then, we changed the course requirements that every PST were expected to write reflection paper only for their own performance for the sake of keeping the quality of their assignments high.

Due to the difficulties encountered in the first implementation, reflection paper-2 was simplified in the second implementation. PSTs were asked to evaluate their teaching performance by answering eight questions provided to them in reflection paper-2. The detailed questions asked in the previous version of reflection-2 were decided to be asked as interview questions to the volunteer PSTs (See 3.4.5). Moreover, instead of detailed reflection as observers, they were asked to make comments to the videos of other groups' teaching performances by answering the three general evaluation questions provided them on LMS. They evaluated their peers' performances by considering the following questions: 1. What are the strengths of the teaching performance of group X?, 2. What are the weaknesses of teaching performance of Group X?, 3. If you were to teach this lesson, would you do anything differently? Explain.

PSTs in the first implementation were expected to write another reflection paper at the end of the semester (Reflection Paper III). In this third reflection paper, they evaluated the re-designed course and their progress during this lesson. The paper was written individually. Their answers to the questions provided in the third reflection paper were analyzed and the results were used to refine the re-designed course before the second implementation.

3.4.5. Post-teaching structured interviews (PTSI)

As it was mentioned, reflection paper-2 questions were used as interview questions in the second implementation. In these interviews, PSTs were asked to evaluate their SSI teaching and technology integration performances (see Appendix D). The questions asked to evaluate PSTs' SSI teaching were prepared based on the SSI framework developed by Zeidler et al. (2005) which identifies four areas of pedagogoical importance central to teaching SSI. Therefore, PSTs were prompted to think about their teaching in terms of (a) nature of science issues, (b) classroom discourse issues, (c) cultural issues, and (d) case-based issues. The other aspect of reflection interviews was the evaluation of their technology integration experiences.

To frame the questions about technology integration, TPACK framework of this study was considered. Therefore, PSTs were asked about their (a) overarching conception about the purposes for incorporating technology in teaching SSI topics, (b) knowledge of students' understandings, thinking, and learning in SSI topics with technology, (c) knowledge of curriculum and curricular materials that integrate technology in learning and teaching SSI, (d) knowledge of instructional strategies and representations for effective SSI teaching with technologies, (e) knowledge of assessment with technology in effective SSI teaching.

There were 20 volunteer participants for these interviews. PSTs were interviewed within the two days following their groups' teaching performances. That is, they were interviewed before their groups' video-stimulated recall interviews (VSRI) to reveal their personal ideas without any impact of group members' ideas. Therefore, the post-teaching structured interviews were scheduled after their teaching performance and before their groups' VSRI.

3.5. Data Analysis

For analyzing the qualitative data, Data Analysis Spiral of Creswell (2007) was followed. The procedures defined in the spiral starts with data managing procedures. For these procedures MAXQDA 12 was utilized. All of the interviews were transcribed verbatim by the researcher and the interview data and other written documents were organized with the help of this software. Following the organization of data, second loop of reading and memoing was pursued. Before starting to code the data, the researcher tried to get sense of the data as a whole. In order to get a sense of the whole database, the transcripts and other written documents were read and memos were written on the MAXQDA project for documents.

The next procedure consisted of moving from the reading and memoing loop into the spiral to the describing, classifying and interpreting loop. In this loop, whole data were coded to produce meaningful segments of the data. The videos were analyzed without transcribing, therefore, the video segments were coded directly with the help of MAXQDA project. Then, categories and themes were emerged from the codes. In analyzing the data, the themes were shaped based on the components of SSI teaching framework. After coding and categorizing them into themes, data was tried to be interpreted to "form larger meanings of what is going on in the situations or sites" (Creswell, 2007, p. 154). In the last step, data was represented in a meaningful way.

3.5.1. Analysis of SSI teaching effectiveness through rubrics

In order to analyze the effectiveness of PSTs' SSI teaching practices, their group lesson plans, individual lesson plans and teaching performances were analyzed. For this purpose, content analysis was conducted. As Patton (2001) described content anaylsis refers to "any qualitative data reduction and sense-making effort that takes of a volume of qualitative material and attempts to identify core consistencies and meanings" (p. 453). Therefore, all qualitative data were content analyzed to find core consistencies and meanings in qualitative material. From emerging codes, categories were formed. Then, patterns were sought to create descriptive findings.

While analyzing the data for effectiveness of PSTs' SSI teaching, four issues, namely case-based issues, classroom discourse issues, nature of science issues and cultural issues were utilized as themes. In order to analyze video recordings of PSTs' teaching performances, codes and categories defined by Simon et al. (2006) to analyze argumentaion processes were adapted to this study.

After the initial analysis of qualitative data through content analysis, a Lesson Plan Evaluation Rubric for Technology Integration into SSI Teaching (LPER-TIST) and Teaching Performance Evaluation Rubric for Technology Integration into SSI Teaching (TPER-TIST) were created to obtain in-depth information about the lesson plans and teaching experiences. These tools also allow researcher to make more systematic comparisons between the group lesson plans and individual lesson plans; and between lesson plans and actual implementation of the plans.

There were ten common criteria in the lesson plan evaluation rubric and teaching performance evaluation rubric. For each criterion, there were four levels. Definitions of each level of each criterion were provided in the rubrics. Sample criterion and the definitions pertaining to the levels of that criterion was provided in Figure 8. Moreover, spaces were provided for each criterion to allow users to include the indicators of their decision.

In order to develop the rubrics, firstly, fourteen criteria were defined based on the categories emerged in the content analysis. Then the criteria and the definitions of the levels of the criteria were reviewed with an expert in SSI teaching field. The criteria were reviewed in terms of their representativeness of the quality criteria of SSI teaching and technology integration based on the literature. Moreover, the criteria written in the observation rubric were reviewed to decide whether it is observable or not. Similarly, the criteria included in the LPER-TIST were also reviewed to decide whether the indicators could be retrieved from the written documents. Then, some of the criteria were decided to be removed from both rubrics, because the criteria of the rubrics were decided to be kept same to allow comparison. Besides, some of the overlapping criteria were also decided to be unified to prevent repetition. As a result of these revisions, ten criteria were decided to be included in the rubrics.

Criteria	**Levels**				
	1-lack of integration	**2-simple integration**	**3-infusive integration**	**4-effective integration**	**Not applicable**
6. Facilitating SSI argumentation of students through technology	- Select technology only to engage students to the issue.	- Select technology to engage students to the issue. - Select technology to allow students to explore and collect specific evidence to produce justification for their own claim	- Select technology to engage students to the issue. - Select technology to allow students to expore and collect specific evidence to produce justification for their own claim - Select technology to help students be aware of the counter arguments related to their claims	- Select technology to engage students to the issue. - Select technology to allow students to expore and collect specific evidence to produce justification for their own claim - Select technology to help students be aware of the counter arguments related to their claims - Select technology to encourage students to do rebuttal to justify their claim in response to the counter-arguments without a fear of personal statements	
Indicators (Provide excerpts)					

Figure 8. Sample criterion of LPER-TIST with definitions of the levels

After deciding the content of the rubrics, they were sent to three experts from SSI teaching field, and three experts from technology integration fields. The expert committee provided their comments for clarification of the levels or the appropriateness of the criteria to technology integration in SSI teaching. The unclear feedbacks were clarified through further meetings with experts and the conflicts were resolved. Then, two of the experts provided their reviews for the revised rubrics. Necessary revisions were done to make the levels more understandable for the users of the rubric.

The testing phase followed the development phase of the rubric. One expert from TPACK field and one expert from SSI teaching field rated 10 percent of the lesson plans and teaching videos. That is, 10 of the lesson plans and two of the teaching videos were rated by two experts in addition to the researcher. Then inter-rater reliability was computed.

To compute inter-rater reliability of the LPER-TIST two commonly used strategies, which are Intraclass Correlation Coefficient (ICC) and Cronbach's Alpha, were utilized. Considering the nature of the rating and the number of raters, ICC was decided as the most appropriate estimate of inter-rater reliability (McGraw & Wong, 1996; Shrout & Fleiss, 1979). There were three different models in ICC calculation. In this dissertation, the same three judges, who were the only judges of interest, rated the target ten lesson plans and two teaching videos. This was called as the third case in Shrout and Fleiss's (1979) paper and two-way mixed method was stated as the most appropriate model for this case. The average measure of ICC was .842 with a 95% confidence interval from .777 to .890 ($F (99,198) = 6.727, p<.001$). Based on the 95% confidence interval, ICC scores between 0.75 and 0.90 was stated as indicative of good reliability (Koo & Li, 2016). Therefore, a good degree of reliability was found between measurements.

Besides ICC, internal consistency was calculated through the most commonly used Cronbach's Alpha procedure (Cronbach, Gleser, Nanda, and Rajaratnam, 1972). Cronbach's Alpha reliability was calculated as .851. The results of the ICC and Cronbach alpha provided evidence for the reliability of the developed rubric.

ICC and Cronbach's Alpha values were calculated for each indicator of the rubric to evaluate the indicators. ICC and Cronbach's Alpha values were calculated for each criterion and the results were given in Table 9.

Criteria 1, 2, 4, and 8 showed a moderate reliability with ICC values between 0.50 and 0.75. The reliability of criteria 3, 5, 6, 7, and 10 indicated good reliability, because the ICC values were between 0.75 and 0.90. Finally, the tenth criterion indicated excellent reliability, because the ICC value was above 0.90 (Koo & Li, 2016).

Same procedures were followed to compute the inter-rater reliability of the TPER-TIST. The average measure of ICC was .806 with a 95% confidence interval from .591 to .917 ($F (19, 38) = 5.029, p<.001$). Moreover, the Cronbach's Alpha value for the whole rubric was calculated as 0.801. Therefore, TPER-TIST indicated good reliability.

Table 9
Reliability Values for the Criteria of the Rubrics

Criteria	LPER-TIST		TPER-TIST	
	ICC	Alpha	ICC	Alpha
1. Troubleshooting strategies for possible problems while using technologies in SSI teaching	.736	.747	.947	.980
2. Providing instructions about students' technology usage in SSI teaching	.693	.693	.828	.960
3. Guiding group work with technology in SSI teaching and learning	.863	.896	.783	.720
4. Using variety of activity types to teach concepts inherent in the selected SSI topic with technology	.661	.800	.960	.960
5. Employing skepticism about potentially biased information reached through technology	.872	.865	.750	.750
6. Facilitating SSI argumentation of students through technology	.855	.883	.938	.938
7. Matching technology to the learning objectives of the science curriculum	.750	.759	.960	.960
8. Monitoring and managing students' progress on technology usage during SSI teaching and learning	.605	.655	.750	.750
9. Using technology to assess students' SSI learning	.943	.947	.750	.750
10. Considering student characteristics in planning technology-integrated activities to engage students in scientific and social inquiry	.750	.766	.750	.750
Total	.842	.851	.806	.801

Note. LPER-TIST=Lesson Plan Evaluation Rubric for Technology Integration into SSI Teaching, TPER-TIST=Teaching Performance Evaluation Rubric for Technology Integration into SSI Teaching.

3.5.2. Analysis of teacher metacognition

In order to reveal PSTs' metacognition, reflection papers, interviews and reflection part of the lesson plans were used. Firstly, all of the data were coded through content analysis. While analyzing data, PSTs commentaries about their thoughts were coded as metacognition rather than the researcher judgments. For example, about the knowledge of pedagogy as one of the metacognitive components, PSTs' rating of their own knowledge necessary to apply the instructional strategy was considered as their metacognition.

Then, based on the codes and categories emerged in the content analysis and the metacognitive patterns of teachers reported by Artzt and Armour-Thomas (1998), PSTs were categorized in terms of their metacognitive thoughts. Twelve categories under eight metacognitive components were decided to be used to categorize PSTs in terms of their metacognitive thoughts. The definitions of the categories were illustrated in Table 20.

In order to decide the appropriateness of the definitions of the categories of metacognitive components, an expert studying metacognition and TPACK provided feedbacks. After necessary revisions were done, one of the authors of the paper explaining Teacher Metacognitive Framework (TMF) was consulted to decide the appropriateness of the definitions of the categories theoretically.

3.6. Design Processes: Development of an Undergraduate Course

There were three phases and eight cycles in this dissertation as it was illustrated in Figure 2. The first phase included two cycles, which include operationalization of the constructs and determining the characteristics of the course design. In these first two cycles literature review was conducted. Therefore, these two cycles and the resulting theoretical framework and design principles were explained in the second chapter in detail.

As it was summarized in the first chapter, evaluation and reflection is not an after-treatment phase that is performed at the end of the study. Therefore, it was not possible to write it as a separate section. There were two types of evaluation in this dissertation. One of them was formative evaluation aiming "to gain insight into the quality of tentative interventions and their design principles and to get revision decisions for developing the next—improved—prototypes" (Nieveen & Folmer, 2013, p. 158). In designing the course, evaluation and reflections were done for the prototypes to improve the next prototype. Moreover, the design principles were revised based on the result of formative assessment. Therefore, it was mentioned in the design and construction phase.

In this dissertation, summative evaluation was also conducted to decide the effectiveness of the re-designed course in reaching the expected outcomes. PSTs' development of effective SSI teaching practices with technology throughout the course and the contribution of the characteristics of the re-designed course in this development was tried to be revealed. Based on the findings, design principles were revised and the final design principles were articulated. Therefore, the third phase, called evaluation and reflection, included the results of the data collected during the implementations. Therefore, it was mentioned in the result chapters (Chapter 4 and Chapter 5) in detail. The second phase of the EDR, called design and construction, was explained below.

The products of the analysis and exploration phase informed the design and construction phase. In light of the design principles constructed based on the literature in the second cycle, prototypes of the course were designed congruent with the theoretical framework of the study determined in the first cycle of the study. There were four cycles (Cycle 3- Cycle 6) in this phase. Each cycle was explained in the following sections.

3.6.1. Cycle 3: Developing the first prototype

By considering the principles of social constructivist learning environment, transformative nature of TPACK and the suggestions for teacher education programs to develop teacher knowledge from transformative point of view, and the role of metacognition in developing TPACK, in this study, an undergraduate course was re-designed to develop pre-service science teachers' effective SSI teaching practices with technology. After determining the main elements of the instructional design of the course, necessary activities were included to increase the effectiveness of PSTs' SSI teaching.

In order to re-design the course, instructional designs with the aim of developing pre-service teachers' TPACK from a transformative perspective were reviewed for this study. As Branch and Kopcha (2014) emphasized "instructional design models serve as a valuable source for matching the right creative process to the right design situation as well as an effective framework for conducting instructional design research." (p. 77). Therefore, the related instructional designs were reviewed to provide a framework for the instructional design of the course.

There were three instructional designs aiming to develop pre-service science teachers' TPACK from a transformative perspective (Angeli, 2005; Angeli & Valanides, 2005; Jang & Chen, 2010). Angeli's (2005) and Angeli and Valanides's (2005) instructional design models and Jang and Chen's (2010) TPACK-COPR (TPACK Comprehension, Observation, Practice and Reflection) have similarities. All three models provide systematic procedures to be followed by researchers or teachers for TPACK development. Moreover, they used design-based learning activities that are developed based on the same epistemological stance. However, there are some differences in the given details of the design principles. Angeli's (2005) instructional design model provided more detailed steps to guide the designed course and the lesson plan preparation of PSTs. On the other hand, Angeli and Valanides (2005) provided more general conceptual elements to be considered by designers aiming to develop teachers' technology integration knowledge. However, neither of the models focused on the inclusion of some steps to introduce the theoretical basis of teacher knowledge to the PSTs.

The TPACK-COPR model was decided to be more appropriate for the aim of this study for some differences from the other two models. This model has four stages as illustrated in Figure 9. Firstly, it includes Comprehension stage that provides chance to develop necessary knowledge bases before engaging in technology integration. Since SSI was a new content area for PSTs to learn and teach, the existence of such a stage is vital for this study. PSTs need to learn the nature of SSI, the theories about the pedagogy of SSI teaching as well as theories about the technology integration for increasing the quality of SSI teaching. Making all the related theoretical knowledge explicit was also crucial to activate PSTs' metacognition by helping PSTs track their knowledge development in the course. Moreover, they could have chance to monitor the effectiveness of their technology integration for reaching the expected outcomes of their SSI teaching. Without knowing the nature of SSI, the pedagogy of SSI teaching and technology integration theoretically, PSTs could not monitor and evaluate the effectiveness of their SSI teaching and the development of their knowledge to reach this aim.

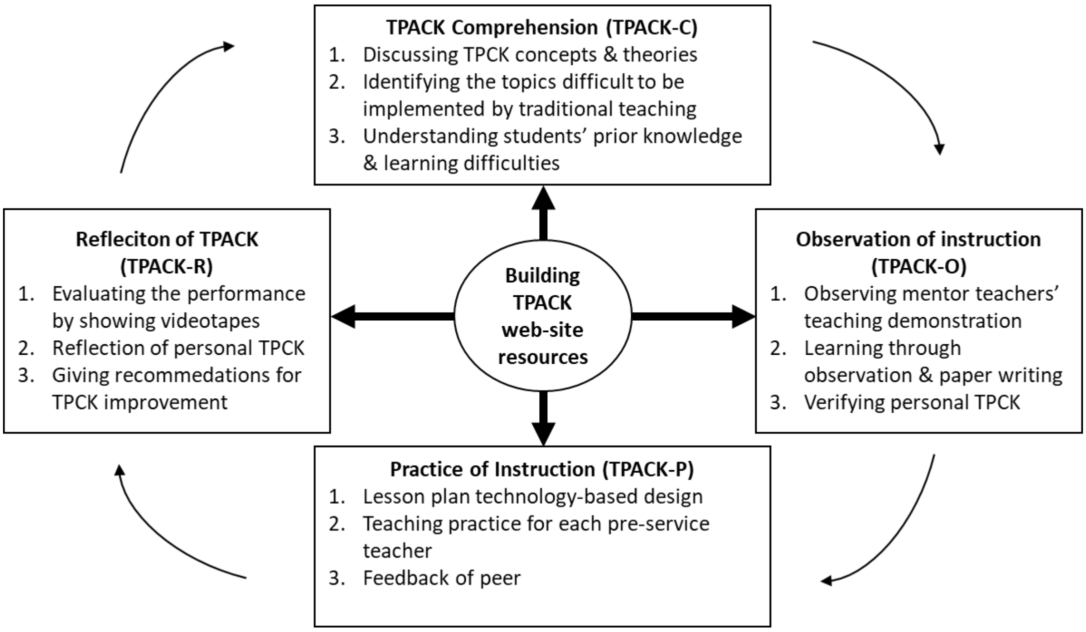

Figure 9. Transformative model of TPACK-COPR (Jang & Chen, 2010, p.556)

Moreover, TPACK-COPR model includes Observation stage that provides opportunity for PSTs to see the best practices of SSI teaching through technology integration. Since identifying exemplars of PCK and their conditions for use is the main characteristics of a teacher education program holding transformative perspective (Gess-Newsome, 1999), providing exemplars of SSI teaching through technology integration was considered as important for this study.

Besides, this model gives chance for PSTs to practice technology integration for effective SSI teaching. The importance of instructional models related to teaching experience has been emphasized by researchers (De Jong, van Driel, & Verloop, 2005; Loughran, Mulhall, & Berry, 2004; Van Dijk, & Katmann, 2007; van Driel, Verloop, & Vos, 1998). Providing practical knowledge for pre-service teachers is important in PCK development, since it is the core of a teacher's professionalism (van Driel, Beijaard, & Verloop, 2001). The importance of experience in developing TPACK was also emphasized in the literature (Jang, & Chen, 2010; Yeh et al., 2014). Therefore, providing pre-service teachers an opportunity to experience effective SSI teaching through technology integration in their teacher education programs is important.

In addition, TPACK-COPR includes a stage for reflection. Encouraging PSTs to think about their thinking before, during and after a technology-integrated SSI lesson was considered important for activating their metacognition. Therefore, engaging PSTs in reflection stage was considered as vital to activate their metacognition about their teaching. Moreover, the cyclic process in TPACK-COPR is in accordance with the dynamic nature of TPACK so that the model enables pre-service teachers to "rethink, unlearn, and relearn, change, revise and adapt" their technology integration knowledge (Niess, 2008, p.225). Therefore, through reflections they can think about the effectiveness of their technology integrated SSI teaching and revise their conceptions to reach more effective SSI teachings. For these reasons, TPACK-COPR was decided to be utilized as the instructional model of the re-designed course. The details of the stages and the main activities followed in the stages and the related design principles were articulated in the following sections.

First Stage: TPACK Comprehension

This stage aimed to introduce the theories and concepts related to SSI teaching, TPACK and teacher metacognition (DP5). PSTs were planned to be given instruction about SSI as a science learning context and the frameworks related to SSI teaching. Therefore, they were introduced with the SSI teaching frameworks. For this purpose, classroom discussions were held to explain the role of case-based issues (DP1), nature of science issues (DP2), discourse issues (DP3) and cultural issues (DP4) and were encouraged to consider these issues in their teachings. Besides, in this stage, instruction about the theoretical framework of TPACK and teacher metacognition was given so that they could relate theory and practice (DP6). In this stage, PSTs were also tried to be persuaded into being engaged in thoughtful thinking about their instructional practice by explaining the positive outcomes of doing so (DP11). Participants were also planned to be informed about the course outline and the requirements of the course. Moreover, it was planned to ask PSTs to form groups to work collaboratively in planning and teaching practices (DP7).

Second Stage: Observation of Instruction

During this phase, pre-service teachers were aimed to be provided exemplary cases for effective SSI teaching through technology integration. At this stage, pre-service teachers were planned to discuss the videos of exemplary cases based on the TPACK components. Moreover, a guest teacher was planned to be invited to explain their school's technology integration policies and his/her technology integration practices, because it was assumed that experienced science teachers' ideas and experiences can serve as a good source for developing PSTs' knowledge for designing instructional materials that enhance students' learning (Hsu, 2015). Moreover, with a sample teaching performance, effective SSI teaching with technology was modelled for PSTs (DP8).

Third Stage: Practice of Instruction

In this stage, pre-service teachers were planned to be given opportunity to gain experience in technology integration through planning and enacting technology-integrated SSI lessons (DP12, DP6). They were asked to prepare a lesson plan collaboratively with their group members (DP7) and implement their plans in the classroom. Therefore, they were given chance to align their theoretical knowledge with practice (DP6). During their preparation to the teaching practice, they were planned to be scaffolded through the prompts embedded in the lesson plan format. Moreover, they were also planned to be guided by the instructor and the teaching assistants of the course about their instructional material design and lesson plan design (DP9).

Fourth Stage: Reflection of TPACK

In the last stage, participants was planned to be asked to reflect on their practice and development of effective SSI teaching practices with technology through reflection papers and interviews (DP10). Moreover, they were engaged in reflection before preparing lesson plans and after their teaching experience to make them aware of their development of effective SSI teaching practices. By answering the prompting questions embedded in the reflection papers, PSTs were planned to think about their knowledge.

3.6.2. Cycle 4: Developing the second prototype

After developing the first draft prototype of the re-designed course, expert reviews were asked from Dissertation Examining Committee. Based on the feedbacks of the committee and another literature review, some changes were decided to be done about the outline of the course and the related design principles. Moreover, the details of the activities that were planned to be conducted in different stages of the course were determined in this cycle.

2.4.3.1. *Reflections on the first prototype and restated design principles*

After constructing the first prototype as a skeleton design, a meeting was arranged with my dissertation examining committee. The appropriateness of the stages of the course and the planned activities concerning each stage was discussed and elaborated. Concerning the dynamic nature of TPACK, committee members advised to include another stage in the model called 'Revision of TPACK'. Therefore, the fifth stage was decided to be added to the TPACK-COPR model by changing its name to TPACK-COPRR (TPACK- Comprehension, Observation, Practice, Reflection, and Revision). Other studies aiming to develop TPACK-based instructional design models admired the TPACK-COPR for its potential to provide PSTs a knowledge base through comprehension stage to understand technology integration (Lee & Kim, 2014). However, those researchers also proposed an adjustment to the model about including a revision stage after the reflection stage. Therefore, in light of the suggestions of the committee members and the literature review conducted for this adjustment, design principles were revised and the below design principle was decided to be added.

> Design Principle 13 (DP13): PSTs should be given opportunity to revise and adapt their knowledge for effective SSI teaching with technology.

As Niess (2008) stated tomorrow's teachers should be facilitated to "rethink, unlearn, and relearn, change, revise and adapt" (p.225). Once they were provided an opportunity to observe and practice technology integration, their abilities to adapt these skills into different technologies or different context should also be investigated and fostered. Therefore, teacher education programs should give pre-service teachers opportunity to apply their gained abilities into variety of contexts.

Moreover, researchers suggested providing opportunity for students to publicly share their work, then to revise their work based on the critiques of others and to reflect on their learning with others in social constructivist learning environments (Ernest, 1995; Woo & Reeves, 2007). Therefore, after constructing their conceptions about effective SSI teaching, PSTs should be provided opportunity to revise their conceptions and reflect their understanding in another project. For this reason, PSTs were expected to prepare another lesson plan at the end of the course considering their observations of good examples, their experiences in teaching SSI and the critiques of their peers and instructors about their performances.

2.4.3.2. ***Second prototype of the re-designed course***

The revised prototype of the course includes five stages. The activities and assignments given in different stages were explained below in detail.

First Stage: TPACK Comprehension

In the first week of the course the LMS of the course, and the course requirements were introduced. PSTs were informed about how to follow the announcements about the assignments in LMS and how to submit their artifacts to the system. Moreover, they were introduced about the working principles of Wiki in which they were expected to prepare their lesson plan collaboratively in the following weeks. Then, PSTs were divided into 8 groups to work collaboratively in the rest of the course for lesson planning and teaching practice (DP7).

In the next week, a brief introduction was done about Science Technology Society approach. The relationship between science and technology was articulated. The role of technology education and technology integration was discussed. Then theoretical knowledge about PCK, TPACK and teacher metacognition was introduced with related class discussions. Technology integration strategies in science education (i.e., supporting authentic science experiences, supporting scientific inquiry skills, supporting science concept learning, accessing science information and tools, Robyler & Doering, 2010) with sample resource and activities was discussed. After general class discussions, PSTs discussed the content of TPACK in groups. Then, in their reflection paper they were asked to include the results of the discussions they held in teams and changes in their conceptions about TPACK after these discussions (DP10).

The other activity conducted for the purpose of contributing to PSTs' TPACK comprehensions was introducing some e-learning tools. After the introductory class discussions about the technology integration strategies in science, a toolbox was provided to them. The purpose of the toolbox was to expand their conceptions of ICT tools' affordances in science education. The toolbox included ICT tools for different purposes in five categories: (1) multimedia (e.g. Youtube, Eba, Phet), (2) presentation (e.g. Animoto, Wordle, Prezi, Slideshare), (3) communication (e.g. Twiter, BeyazPano, GoToMeeting), (4) collaboration (e.g. WriteBoard, Mindomo, Thinkature), (5) organization/mapping/storage (e.g. Edraw, Educreation, Dropbox), (6) metacognition/planning (e.g. Blogspot, Ta-da-list, Clocking IT). For encouraging their exploration of the tools, some of the tools from different categories were introduced. For example, one of the concept-mapping tools was explained shortly while also remembering the characteristics of a concept map. Then, they were encouraged to include the concept maps prepared with one of the concept mapping tools provided in Toolbox in their reflection paper for explaining their conceptions of TPACK for effective SSI teaching. At the end of the first stage, PSTs were asked to prepare a reflection paper (DP10).

Second Stage: Observation of Instruction

In the second stage, good technology integration practices in science education were illustrated to the PSTs. For this purpose, a technology integration video case created by INTIME Project was shown to the PSTs. From the database including videos from different content areas and grade levels, a six grade science lesson "WebQuest Solar System Colonization Project 2000" was chosen purposefully, because it was considered as an effective example for technology integration in SSI teaching (University of Northern Iowa & National Science Foundation, 2000) (DP8). In this video case, 6the grade students were given a task through a WebQuest that teacher designed: “In a futuristic setting in which overpopulation has caused catastrophic problems for our planet, students will be asked to explore two questions: Where should a space colony be built? And what adaptations will be needed to support life at that location?”. To reach a decision, students were expected to collect, analyze and interpret data about the livability of different location on space from different perspective. The groups searched data in the role of astronomer, meteorologist, geologist, psychologist/sociologist, or biologist. Then, they were expected to prepare a presentation about their choice of location for construction of a space station by providing evidences from different perspectives. Although this is not a real issue, it can be considered as a socio-scientific issue. Before and after watching the video about implementation of the activity in the classroom, PSTs were guided to engage in a group discussion with the questions provided in the video case in INTIME webpage.

In order to provide more local example to PSTs for being role model about technology integration in their future classrooms, a science teacher was invited from the Foundation School of the university. The invited teacher made a presentation explaining their technology integration processes including planning, material development, video-recording of their technology-integrated lessons for self-evaluation and to get feedback from their colleagues. Then, the teacher showed video clips from their technology-integrated science lessons. Moreover, she explained the school’s technology integration in assessment with online homework. She explained that students were given online homework regularly about each topic and according to their test results; they were provided additional instructional materials to be read or watched. After the teacher shared her experiences with PSTs, she answered their questions.

Another example technology integration was provided through sample teaching performance about an SSI topic. I prepared a sample lesson plan and enacted it in the classroom after the lesson plan template was introduced to PSTs. In this sample lesson plan, I addressed the Global Climate Change as socioscientific issue. To foster students’ investigations about the Global Climate Change, I constructed a project through Web-Based Inquiry Science Environment (WISE) web-page. I tried to exemplify the use of inquiry-based web activities with different tools like remote control of students' computers for classroom management or online quiz for assessment.

In this stage, lesson plan template and the embedded prompts were explained to the PSTs. They were also informed about how to use Wiki for the purpose of preparing lesson plan collaboratively.

Third Stage: Practice of Instruction

Third stage was the longest one. Each of the eight group practiced the designing and enacting of a lesson plan in this stage (DP6, DP12). Groups prepared their lesson plans by using their own Wiki page. At the beginning of the stage, they first prompted to select an SSI to be covered in their lesson. While they were trying to select a proper SSI, groups were scaffolded by the course assistants through the comments from the group Wiki pages (DP9), so that they selected relevant and meaningful SSI topics to be covered in their teaching performance (DP1). After deciding their SSI topic, groups were prompted to seek for the possible pedagogical strategies to cover their topic. At this point, groups were guided to use argumentation as the most appropriate pedagogy for SSI teaching in the class discussions with theoretical background information (DP3). After deciding how to cover SSI in their lesson, groups were prompted to seek for instructional technologies to leverage their teaching and learning processes. At this point, groups were suggested to use the Toolbox to find possible technologies for their purpose. Groups tested different technologies for different purposes and decided the most appropriate ones.

After completing the lesson planning, groups enacted their plans in the classroom. The teaching performances of the groups lasted between 40-60 minutes. The group members shared responsibility both in planning and teaching process and each member contributed to the process (DP7). At the seventh week groups started to perform their lesson plans. Each week, two groups performed their teaching and the teaching performances lasted 4 weeks in total.

Fourth Stage: Reflection of TPACK

This stage was not considered as an after-teaching phase started at the end of the teaching performances. Instead, they were guided to reflect their own knowledge at different points in the course. After engaging in class discussions about theories and concepts in the comprehension phase and before starting to prepare their lesson plans, PSTs were asked to reflect on their understanding about SSI teaching and TPACK. By this way, they were made to monitor their progress in the course.

Another reflection was done after teaching practices. Groups' teaching performances were videotaped. As soon as groups performed their teaching, video recordings of the performances were uploaded to LMS to be watched and reflected on by each PST. After watching their groups' performance, each group members were expected to write a reflection paper (reflection paper-2) to analyze their teaching both in terms of SSI teaching and technology integration due the next week of their performance. At the end of the third stage of the course, each PST was expected to write another reflection paper (reflection paper-3) to reflect on their TPACK development for effective SSI teaching. At this reflection paper, PSTs were asked to describe their TPACK development for effective SSI teaching after each stage of the re-designed course.

These reflections were planned to serve PSTs tools for self-evaluation of their current lesson plans and teaching practice (DP10). Their insights gained in this stage would be used in the next stage. Moreover, these reflections were used as a data source for the revision of the re-designed course.

Fifth Stage: Revision of TPACK

This stage was comprised of the last two week of the course. After PSTs went through the whole process of the re-designed course, they were asked to prepare a new lesson plan individually (DP13). They were suggested to consider their reflections and their experiences they gained in group lesson planning and teaching practice while preparing another lesson plan. Since they analyzed the strengths and weaknesses of their lesson plans and teaching practices with reflection papers, they were supposed to reflect this information to revise their thinking and prepare another lesson plan accordingly.

3.6.3. Cycle 5: Developing the third prototype

The second prototype of the re-designed course was implemented in 2014-2015 Fall semester. Data was collected through different data collection tools. The data collected from the lesson plans, reflection papers and interviews were used to understand the PSTs' development of SSI teaching practices with technology. Moreover, the data was also used to revise the design of the course. Based on the results, one of the design principle was restated and a new design principle was included.

3.2.3.1. *Reflections on the second prototype and restated design principles*

In this re-designed course, our main purpose was to develop PSTs' effective SSI teaching practices with technology. For this reason, they were given opportunity to develop their theoretical and practical knowledge throughout the course. They were asked to rate their knowledge development in the reflection papers written at the beginning and at the end of the semester. They rated their technology, content (SSI), pedagogy, and TPACK knowledge from 1 to 5. When their ratings were examined (Table 10), it can be clearly seen that their confidence about these knowledge areas developed throughout the semester based on their own ratings.

While PSTs rated their SSI knowledge 3.53 out of 5.00 in the first reflection paper, their ratings of their SSI knowledge increased to 4.39 in the last reflection paper. Similarly, they rated their pedagogy knowledge 3.85 in the first reflection paper and 4.33 in the last reflection paper. Their ratings of technology knowledge and TPACK also increased from 3.74 to 4.39 and from 33.37 to 4.14, respectively.

Table 10
PSTs' Ratings of Their Knowledge Development

Knowledge Dimensions	Mean	
	Reflection Paper_1	Reflection Paper_3
Content Knowledge	3.53	4.39
Pedagogy Knowledge	3.85	4.33
Technology Knowledge	3.74	4.39
Technological Pedagogical Content Knowledge	3.37	4.14

PSTs' stated in the first reflection paper that either they did not know what SSI is or they had limited knowledge about SSI.

> "I nearly had no idea about this situation. Yes. I know we should give daily life examples to students for making knowledge permanent however I do not know how to do this through SSI teaching." (FI_G7_BB, RP_1)

They stated that they feel themselves insufficient in following societal issues related to science and technology.

> "My content area knowledge regarding socio-scientific issues in the classroom'3', because I cannot follow socio scientific issues all the time, I have to read more newspaper and journal." (FI_G4_BKI, RP_1)

However, at the end of the course they stated that they had chance to teach SSI and participate discussions about SSI as students. Therefore, these discussions broadened their understanding of SSI and the role of SSI in science education as one of the PSTs' below statement.

> "After this course, I can say that I have the most idea about this issue. All done teaching performances, selected socio scientific issues etc. cause for me to understand socio-scientific issue concept in detail. In addition, this course provides the opportunity to follow socio-scientific issues closely for me." (FI_G6_BE, RP_3)

PSTs' rating of their pedagogical knowledge was also increased. At the beginning of the course, their rating were also high. They stated that they took many courses contributing to their pedagogical knowledge. Therefore, they felt themselves confident in their pedagogical knowledge. However, they stated that they need experience to become totally confident in their pedagogical knowledge. At the end of the semester, they stated that thanks to the opportunity of practice of SSI teaching, their confidence about their pedagogical knowledge increased.

> "I think that my pedagogical knowledge was good because I took many effective courses such as introduction to education, educational psychology, instructional principles and methods, measurement and assessment, laboratory applications in science, methods of teaching science, classroom management, community service and school experience at university. With these courses, I broadened my horizon and gained different point of view about pedagogical knowledge a lot. During this semester, with science, technology and society course, I learned and improved myself about how I can manage the class effectively while I am teaching socio-scientific issues by integrating these topics with technology. Thanks to preparing lesson plans which includes socio-scientific issues and teaching performances in this course, I improved myself about pedagogical knowledge So, I rate myself higher as compared to the first rating." (FI_G2_AK, RP_3)

According to PSTs' ratings, their technology knowledge also increased in this course. They stated that since they did not much opportunity to apply their technological knowledge, they had concerns about their technological knowledge at the beginning of the course. However, using technology actively helped them to overcome their fear about technology usage; therefore, their rating increased in the last reflection paper as it can be seen in the following quotation.

> "I can give 4 point for my technology knowledge in the classroom. Actually, at the beginning of the semester, I answered the same question by giving 3 point for myself but I should give 2 point because I feared technological devices and was afraid not to be able to use these devices in front of the students. However, now I trust myself more." (FI_G1_BK, RP_3)

According to their statements, engaging in collaborative work also contributed to their confidence of using technology. One of the PST stated that existence of more knowledgeable peer in their group helped her feeling confidence about overcoming her fear of technology usage.

> "Actually, I have some doubts about using technology in classes because I do not feel enough in terms of use of technology. I realize during the group discussion I feared technology. However, at the end of the discussion I noticed that I can overcome my fears. Because one group friend know everything about technology and he encourage me to be able to succeed this." (FI_G1_BK, RP_1)

By designing a social constructivist learning environment, one of our main purpose was also guiding them to learn from each other and construct and develop their knowledge in the social environment. Therefore, we assumed that grouping PSTs to work collaboratively in designing technology-enhanced SSI teaching lessons and implementing their plans was an effective way in contributing to their development.

PSTs' ratings of their technological pedagogical content knowledge were also higher in the last reflection paper. Their understanding about the meaning of TPACK also changed. They were asked to define their understanding of TPACK in their first and last reflection papers. They tried to write definition of TPACK with their own words as it was summarized in Table 11.

Table 11
Changes in PSTs' Definitions of TPACK

Definition	Reflection Paper_1	Reflection Paper_3	Total
The combination of technology, pedagogy and content knowledge	18	4	22
Using technological and pedagogical knowledge to make content more suitable for students	2	9	11
Effective pedagogical practice enhanced with technology	4	6	10
A form of strategic thinking	-	5	5
Using technology to make lessons more comprehensible	3	2	5
Knowledge of how to use technology to teach subject	2	3	5
Integration of technology into pedagogical content knowledge	1	3	4
Using technology in accordance with curriculum	-	2	2
Professional technology usage skill	-	2	2
Being aware of advantages and disadvantages of various technologies	-	2	2
Using technology in accordance with instructional strategy	1	1	2
The relationship between T, C, P knowledge domains that are affected by the needs of society	-	1	2
Total	31	40	71

In their first reflection paper, more than half of the PSTs (n=18) defined TPACK as the combination of technology knowledge, pedagogy knowledge and content knowledge. However, they did not provide any detail about the nature of this combination. They only interpreted what they saw in the generally used Venn diagram of TPACK, but did not explain the intercept of three knowledge domains. In the third reflection paper, only four of the PSTs defined TPACK in this way. A typical definition of PSTs in the first reflection paper was as follows:

> "According to me, technological pedagogical content knowledge is combination of Technology Knowledge, Pedagogy Knowledge and Content Knowledge" (FI_G6_BE, RP_1)

In the third reflection paper, PSTs mostly defined the construct as "Using technological and pedagogical knowledge to make content more suitable for students". This definition includes a purpose for the integration of technology, pedagogy and content knowledge and emphasizes the consideration of students in this integration as in the following examples.

> "Good technological and pedagogical knowledge makes the lesson effective and facilitate the transfer of the content knowledge." (FI_G8_CAY, RP_3)

> "TPACK is the knowledge about the course content that technology is integrated and appropriate instructional methods are used." (FI_G2_SK, RP_3)

Another frequently stated definition of TPACK mentioned in the third reflection paper was "Effective pedagogical practice enhanced with technology". Four of the PSTs in the first reflection paper and six of the PSTs in the third reflection paper defined TPACK in this way. A typical definition of TPACK in this way was given in the following quotation.

> "TPACK is a framework to understand and describe the kinds of knowledge needed by a teacher for effective pedagogical practice in a technology enhanced learning environment." (FI_G5_SA, RP_3)

Although none of the PSTs defined TPACK as a form of strategic thinking in the first reflection paper, they defined TPACK in this way in the third reflection paper. They emphasized teachers' thinking in this definition by considering different elements of science teaching as it can be seen in the following quotations.

> "Thinking the teaching process as a relationship of content, teaching and technology, and preparing lesson flow by considering them give advantage to teacher to serve students' meaningful learning, efficient

> classroom management and relate the science class with NOS aspects, SPS and Socio-Scientific issues and as a result dynamic classroom environment can be occurred.” (FI_G7_FB, RP_3)

> “It is the way of planning and organizing a lesson strategically according to content and specific students’ needs by using technologies.” (FI_G1_ŞK, RP_3)

Other definitions that were stated only in the third reflection paper were “Using technology in accordance with curriculum”, “Professional technology usage skill”, “Being aware of advantages and disadvantages of various technologies” and “The relationship between T, C, P knowledge domains that are affected by the needs of society”. The common point in all these definitions was that PSTs considered the effects of some criteria like curriculum or added value of the technology on teachers’ technology integration. Therefore, beyond saying only the integration of T, P and C, PSTs mentioned about how teachers can integrate these knowledge domains and what teacher should consider in this integration.

PSTs were expected to write the first reflection paper at the end of the comprehension stage of the course. That is, after explaining and discussing what entails the content of TPACK theoretically, they tried to explain their understanding of TPACK in the first reflection paper. After experiencing the whole process in the course, comprehending, observing, practicing and reflecting, they were expected to write their understanding of TPACK again in the reflection paper 3. Although they did not internalize the theoretical definition of TPACK at first, TPACK started to make more sense at the end of the course.

Moreover, when their definitions of TPACK in the first reflection paper were examined, it can be seen that their definition lacked of clear purpose of increasing the effectiveness of teaching. On the other hand, in their later definitions, they mentioned increasing the effectiveness of SSI teaching or meeting the students’ need through technology integration. Their practices about SSI teaching with technology can be influential in this difference in their definitions. This supports the sixth design principle. Giving PSTs opportunity to learn theoretical knowledge and to apply their knowledge in their teaching performance helped them to develop an understanding about effective SSI teaching with technology.

After observing different role models, experiencing lesson planning and teaching, they started to think about SSI teaching and TPACK in detail. Therefore, it can be inferred that the stages included in the course were needed for development of effective SSI teaching with technology. Therefore, based on these results, it was decided to use the same stages in further implementations. However, some revisions were done in the contents of the stages based on the data obtained in the first implementation.

3.6.3.1.1. Revisions in TPACK-Comprehension stage

In the reflection paper 3, PSTs were asked to evaluate the re-designed course. For this reason, they were asked to explain how the different stages of the course contributed to their development of effective SSI teaching practices with technology. Based on the PSTs' critiques for different stages, some revisions were decided to be done.

All of the PSTs stated that they did not hear about SSI teaching and TPACK before the course. Therefore, they stated that introductory lessons were informative for them in comprehending TPACK and SSI theoretically, as they stated in the following quotation.

> "Actually, before taking this course I have not much information about Technological Pedagogical Content Knowledge and SSI. Firstly, I learned these concepts from in introductory lectures. The instructor's presentations influenced my knowledge especially. I learned a lot from what she shared and said to us". (FI_G5_RD, RP_3)

Moreover, PSTs stated that the introductory lectures and class discussions changed their views about the importance of teaching SSI and technology integration in science education. They stated that they realized the importance of SSI teaching and integrating technology in their SSI teaching.

> "I did not know the importance of teaching socio-scientific issues and using technology in a science class. I think, thanks to the lectures, I learned these well and I will use the technology effectively in my teaching life." (FI_G5_SA, RP_3)

> "I had never thought about the way how these are incorporated with each other and also integrated in the lessons and how much the integration of these to lesson is important?" (FI_G2_BU, RP_3)

PSTs also stated that the introductory lectures helped them to think about the ways of technology integration. In this stage, after the class discussions about theoretical information, lesson plan template was also explained. Therefore, they were activated to think about how they can reflect their theoretical knowledge they gained in the lectures to their lesson plans. Therefore, as it can be seen in their statements, they changed their conceptions about technology integration and tried to think technology integration congruent with the curriculum goals.

> "I understand that technology integration is not just doing presentations in the lesson with projector and power point. We can make our lessons very different and enjoyable with help of technology." (FI_G7_CA, RP_3)

> "Lectures helped me understand curriculum deeply and think about how I can apply my learning to my lesson plans." (FI_G7_FB, RP_3)

Some of the PSTs emphasized the role of toolbox in changing their thinking about technology integration into SSI teaching. They stated that when they saw the examples of different technologies that can be used for different purposes, their views about technology integration changed.

> "Teacher also showed the wiki and how we use it. This is the different technology for us. We did not hear before. Teacher also explained what alternative technological things are used. These activities are so beneficial for our future and current practices of SSI teaching." (FI_G8_EY, RP_3)

Considering their emphasis on the role of toolbox in comprehending TPACK for effective SSI teaching, it was decided to be extended for using in further implementations. The number of the examples to technological tools was decided to be increased. Moreover, the categories for the purposes of the use of these technological tools were revised to meet their needs for finding useful instructional tools to increase their SSI teaching effectiveness.

Overall, all of the PSTs acknowledged the contribution of the activities in this stage on their development of effective SSI teaching practices with technology. They were also asked to explain the challenges they faced in this stage. Only two of them mentioned their difficulty in understanding TPACK.

> "I have suffered the difficulty to explain the interrelation of each area. I still need to think and read more about them." (FI_G7_FB, RP_3)

By considering the concern of this PST, documents explaining TPACK was decided to be offered as supplementary readings so that PSTs who have difficulty in understanding can read these readings to extend their understanding.

In terms of developing PSTs' understanding of TPACK, this stage was decided to be useful. Therefore, except for including supplementary readings and extending the toolbox, no other revision was seen as necessary. However, as it was explained in the following sections, PSTs had difficulty in understanding the nature of SSI before starting to lesson planning process. Although there were articles helping them comprehend SSI, all of them were not covered before PSTs started to prepare their lesson plans. Therefore, the course syllabus was revised to cover all the articles before passing to the next stage.

3.6.3.1.2. Revisions in TPACK-Observation stage

PSTs stated that they have learned most by observing their peers' teaching practices. According to their statements given below, observing other groups' teachings increased their repertoire. They had chance to see different examples.

> "I have learned many thing from my friend and noted my observations for my future performances" (FI_G7_FB, RP_3)

> "Also I have learned many programs and applications from my friends. They used different and well-designed programs that I can apply in my future classrooms." (FI_G5_RD, RP_3)

Especially, the PSTs in the later groups had chance to see other groups' performances and reflect their learning to their own lesson plans.

> "We learned from others' performances in a positive or negative ways and we developed our lesson plans and performances accordingly." (FI_G6_SET, RP_3)

> "After each group performance, we learned new teaching approaches about integration of technology, content and knowledge that will be useful in development of our plans and performance."(FI_G6_RO, RP_3)

PSTs also emphasized the role of the sample teaching performed by teaching assistant of the course on their development of effective SSI teaching practices with technology. As they stated in the below quotations, by observing the sample teaching, they also had chance to see a new way of technology integration in science courses which they were not accustomed to.

> "We learned how to use technology and integrate it in SSI teaching. We saw the implementation of TPACK, which we learned from the lecture. We learned new technologies to be used in SSI teaching from teaching assistant. We should not use only computer or games or videos. We can make a web site like teacher and we will use just like we want." (FI_G8_CAY, RP_3)

> "We observed different types models about SSI teaching with technology in this course time. Our instructor has tried to show us the usage common and famous tool like wiki every lecture time. Also, both our assistants and our classmate showed us many different tools like one drive, wordpress, blog, dropbox to create more effective educational environment for SSI teaching and to allow participation of more students. By this way, we had a chance to see many different educational technologies s to use in our future SSI teaching practices." (FI_G8_EY, RP_3)

> "I learned from teaching assistant of the course to use different special web page that is prepared for students to make lesson more concrete. She also showed us how to use wiki environment to solve our communication problem. We only focused on video when we have to use technology in our lesson. I recognized that web page or blogs can be prepared for our SSI teaching lessons." (FI_G8_ME, RP_3)

Especially for the previous groups, sample teaching performance served as a concrete example of the theoretically discussed issues about SSI teaching and technology integration.

> "Observing the sample teaching performance was very beneficial for us to have concrete clues about how we can do SSI teaching." (FI_G2_BU, RP_3)

Observing other groups' and teaching assistant's performance gave PSTs chance to learn how to integrate technology in SSI teaching effectively as well as to become aware of their own capabilities. Moreover, as they stated in the below quotations, observing other groups' weaknesses and strengths increased PSTs' awareness about their own abilities.

> "By observing, I saw and understand my weaknesses and strengths about technology integrated lesson plans and teaching performances." (FI_G2_AK, RP_3)

> "While observing our classmates' teaching, I see their weakness and strengths about TPACK.I also observe how the classroom environment can be. I learnt many things from their teaching performance because we all have different perspective." (FI_G5_DC, RP_3)

One of the PSTs mentioned about the impression of video case PSTs watched in this stage. The PST stated that the technology used in the video impressed her and they tried to integrate a similar technology in a similar way in their group lesson plan.

> "The model that I am affected more is the webquest example that is prepared by Vicki Oleson who is a teacher in Northern University Middle School. Then in our group lesson plan, we try to apply this model as a blog that guide students to researching about their issue, filling data tables and planning argumentation." (FI_G7_FB, RP_3)

When PSTs were prompted to reflect on the activities conducted in this stage of the course, PSTs mostly referred to the contributions of their observations of their peers and sample teaching in their development of effective SSI teaching with technology. Except one PST, they did not acknowledge the contribution of video case offered them in this stage. This situation was interpreted that the video was not from our own context. It was recorded in USA in INTIME project. Therefore, PSTs may not feel intimate with the teacher and the classroom context in the video. Therefore, it was decided to remove the video case from this stage in further implementations.

The most stated effect of the observations was about other groups' performances. Therefore, PSTs were decided to be guided to think more about other groups' teaching performances. For this reason, in the second implementation, PSTs were asked to write comments to other groups' performances in LMS. Since thinking on other groups' strengths and weaknesses increased their awareness about their own abilities, they were asked to think about and analyze other groups' performances. To increase the effectiveness of their comments, some prompting questions were asked. They were expected to reflect on other groups' performances by considering the following three questions:

- What were the strengths of the teaching performance of group X?
- What were the weaknesses of teaching performance of Group X?
- If you were to teach this lesson, would you do anything differently? Explain.

Moreover, PSTs also emphasized the influence of sample teaching performances on their development of effective SSI teaching practices with technology. Therefore, in the second implementation, sample teaching performance was enriched with variety of technological tools to offer PSTs observation opportunity for the integration of different tools for different purposes. For this purpose, video, Prezi, Kahoot, Webquest, and OneDrive was used to exemplify the use of technology for different purposes.

In their third reflection paper, none of the PSTs mentioned the influence of guest teacher on their development of effective SSI teaching practices with technology. However, in other data sources, they frequently refer to real classroom context as influential factor in their SSI teaching and technology integration. For example, while rating their abilities in technology integration, one of the PSTs mentioned that she could not foresee the effect of the school-level barriers, therefore, she stated that she cannot evaluate herself realistically.

> "I'm good in technological background, content knowledge and pedagogical content but there are many reasons that affect the classroom environment. For example the technical background of school, the number of students we have in class, other teachers, school policies etc. I don't know their effects to my teaching procedure. But on the other hand I believe that, I can choose the way to reach my students by using technology such as Internet." (FI_G7_FB, RP_1)

Moreover, during class discussions held in this stage, PSTs stated that they did not have knowledge about the context of the schools, so that they fell in conflict about the possibility of seamless technology integration in the current context of the schools.

> "During the class discussion, we sometimes focused on different point such that I said technological devises like projection generally require time to be set up correctly. However, my group mates refused my mind by saying that with be regulated educational system and our curriculums, many school should have technological devises which is ready to use every time in classes especially science classes. Then, all of us thought that with technology, we may teach our topics more enjoyable and effectively." (FI_G8_EY, RP_1)

Furthermore, while talking about the difficulties they faced in SSI teaching practice with technology, they frequently stated in their video-stimulated recall interview that the situation would be different in real classroom context. On the other hand, although they thought that they were effective in technology integration in this simulated classes, they would not be effective in real classroom context.

All these statements of the PSTs made us think that they need to have information about the real classroom context. Therefore, although they did not mention the effect of guest teacher's speech on their development of effective SSI teaching practices with technology, it was decided to keep it in further implementations. However, in order to increase the efficiency of this meeting with the guest teacher, the content of the presentation of the teacher was determined in close collaboration with the teacher by considering the needs of PSTs. We determined what PSTs need to know based on the results of the first implementation. Guest teacher tried to cover those issues in his presentation.

Based on the findings, one of the design principles decided to be revisited. In the eighth design principle it was stated that PSTs should be provided role models of effective SSI teaching with technology. In this study, PSTs mostly regarded their classmates who had effective SSI teaching practices as role models. They mostly stated that they learned from each other. They thought that they can accomplish when they observe their friends who accomplished effective SSI teaching with technology. A typical quotation for this type of thinking can be given as:

> "Actually, in their teaching performance, my friend has used Prezi presentation to teach SSI to students and I have realized that we can use Prezi in classrooms." (FI_G1_BK, RP_2)

This can be explained with the role of vicarious experiences as a powerful tool in changing teachers' views (Ertmer, 2005). Both in the literature on self-efficacy beliefs and technology professional development, it was frequently emphasized that 'observing similar others' can be used as a tool for teacher development for its informational and motivational contribution to teacher knowledge (Ertmer, 2005; Schunk, 2000). As Ertmer (2005) stated that "models can not only provide information about how to enact specific classroom strategies, they can also increase observers' confidence for generating the same behaviors." (p.33). Therefore, in line with literature, our study showed the importance of PSTs' learning from observing of their peers. However, the phrase 'observing similar others' is key at this point. Because PSTs made profit from their observation as far as they observed similarity with themselves. For this reason, while mentioning the contribution of their observation on their learning, they mostly referred to their peers and then, to instructor of the course. They did not mention about the role of the observation of the teacher in the video case on their development of effective SSI teaching, since they might not be able to find similarities with themselves. Based upon this result, we decided to revisit our eighth design principle.

> Design Principle 8 (DP8): PSTs should be provided role models of effective SSI teaching with technology, which shows similarity with them.

In addition to the sample teaching of the teaching assistant, PSTs admired the role of instructors' technology integration into the course in their development of effective SSI teaching practices with technology. They stated that the use of Wiki spaces and effective use of learning management system of the school changed their views about technology integration. They started to think technology beyond showing video or making presentation with PowerPoint presentation. They also saw how technology facilitates the instructional processes throughout the semester. Actually, that was in line with our purpose that we aimed to serve as role model in technology integration, because we tried to create a social constructivist learning environment. At the beginning and throughout the semester we emphasized why we selected to use the particular technologies and we stated our purpose explicitly. The literature shows that teacher educators can serve as a role model implicitly or explicitly. Studies indicated that discussing the intend of technology use through thinking aloud has a great potential in presenting thinking of the teacher educator and the pedagogy used (Lunenberg, Korthagen, & Swennen, 2007). PSTs' emphasis on the role of used technologies in the scope of the re-designed course in their development of effective SSI teaching with technology also indicated the positive effect of explicit modeling of technology integration. Therefore, in order to increase the effectiveness of further implementations another design principle was decided to be added.

> Design Principle 14 (DP14): Teacher educators should provide explicit modeling about their own technology integration into SSI teaching practices.

3.6.3.1.3. Revisions in TPACK-Practice stage

PSTs discussed the challenges they faced during lesson planning and enacting their plans. The most vital problem that PSTs faced was about selecting the SSI topic. Two of the groups could not decide a proper SSI. Their topic was only environmental issue or a topic about environment. Their topic selection also caused problems in subsequent processes. Since they were not able to select an SSI, their instructional strategy could not be argumentation. They only planned to use discussion to make their students discuss about the topic they covered.

> "Actually we couldn't decide the socio-scientific issue because our plan was not SSI. Consequently, we didn't have an argumentation part. We only had small discussion." (FI_G3_CY, RP_3)

> "Our instruction told us to use argumentation strategy. However, we confused argumentation with discussion. In the lesson there should be controversial issue. However, we could not create argumentation environment." (FI_G4_SNA, RP_3)

The most probable reason of this situation was that they did not conceptualize what SSI is until they started to prepare their lesson plans. PSTs were expected to start planning before discussing each reading about SSI offered in the course. Therefore, it was decided to make a revision in the re-designed course to handle this situation. Before the observation stage, all the readings were decided to be discussed. Therefore, PSTs would discuss the SSI theoretically. Then, they would have chance to see an example for how to address the characteristics of the SSI topic in teaching through the sample teaching performance. After these processes, they were expected to start lesson planning, although they were activated to think about the SSI that they will cover from the first weeks.

The other reason of this situation was stated as their difficulty in communicating with the teaching assistants through Wiki pages. They were frequently prompted to explain their decisions about their topic, instructional strategy or technology selection in Wiki discussions. However, they preferred to prepare lesson plan without any discussion held in online environment for getting feedback about their processes. Therefore, this situation was decided to be handled in the second implementation. Although we decided not to do any revision in the course requirements, we planned to lay emphasis on the need for them to participate in online discussions for getting feedbacks. Therefore, PSTs were warned to respond the prompting questions provided them in their Wiki discussion pages regularly. Moreover, if they had difficulty in using Wiki spaces, they were encouraged to use other online discussion environments as long as they invited the teaching assistants. Thus, we would have chance to monitor their progress in their plans and intervene their decision making process when needed.

Other groups also struggled in SSI selection. They had difficulty in deciding appropriate SSI for students' level. They overcame this issue by consulting the curriculum as one of the PSTs stated in the following quotation.

> "While we were deciding the socio-scientific issue, we faced the challenge about whether the socio-scientific issue we teach is appropriate for students' level or not. We tried to cope with this challenge by choosing the socio-scientific issue from science curriculum although there is limited socio-scientific issue in science curriculum." (FI_G2_AK, RP_3)

There were also other challenges PSTs faced during planning, although they did not cause major problems as SSI selection. Since PSTs were not accustomed to prepare lesson plans with the template offered them to activate their thinking about their decisions in each step, they became bored to answer the prompting questions. Moreover, they stated that there were some questions that were difficult to understand.

Based on their feedbacks, minor revisions were done in prompting questions in order to increase their clarity.

Besides, two PSTs stated that they had difficulty in selecting technologies to be integrated in their SSI teaching. They stated that there were limited alternatives for the technologies that can be used to teach SSI. To overcome this problem, as it was mentioned previously, toolbox was extended and variety of example technological tools was included in the file. Moreover, sample teaching performance was revised to increase the variety of technological materials to provide more examples to PSTs.

PSTs also mentioned some challenges they faced during their teaching performances. The most frequently stated challenge in teaching was timing of activities. While evaluating their teaching performances in VSRI and reflection paper 2, PSTs frequently talked about their time management problems.

> "We have had trouble with time issue and in order to overcome it, we have tried to be quick as much as possible but we have failed in this regard." (FI_G1_BK, RP_2)

Although some of the PST hold the students accountable for this situation, some of them stated the need for revision in their activities.

> "However, while integrating it in teaching sequence we faced with some problems like time management. Some of students in groups did not participate in lesson and encouraging them for participation caused loss of time that allocated for the activity. So, we had to skip some parts of the activity. If we have a little more time for teaching performance, we could overcome such problems." (FI_G6_RO, RP_3)

> "The questions of prepared case reports on the internet for each group were too much. So, students have spent a lot of time for it. Using technology from students took much time than I expect." (FI_G6_BE, RP_3)

> "Actually, the only problem in group work was having excessive number of questions. This took too much time." (FI_G1_MBT, VSRI)

They stated that they were not realistic about timing in their plans. They could not foresee the problems that may occur in teaching or the time requirements of the activities.

> "We always looked at the clock. Students are slower than we expected. Thefore, time was not sufficient. For example, the activity that I thought it would finish in 10 minutes extended up to 20 minutes." (FI_G5_DC, VSRI)

Some PSTs thought that students' technology usage caused the delays in the planned activities so time management problem occurred.

> "I and my group members faced with time management problem. Students waste lots of time with making researches via computers. It made us face with time management problem." (FI_G6_BY, RP_3)

They stated that, in order to implement argumentation effectively the time given for teaching performances was not enough. Similarly, the groups who did not implement argumentation (i.e. Group 3) stated that they did not have any time management problem.

> "We had time issue, this argumentation needs more time than we have. I saw that if I use this lesson plan in a real class, I will totally give two hours at least, so students will not have to rush to share their ideas, and I can ensure relax class environment." (FI_G7_BB, RP_2)
>
> "We cannot manage the time effectively. If we were quick, students cannot find evidences or there would be inequity among our team member (FI_G1_MK, RP_2)
>
> "We could manage our time effectively. We did not lose too much time for technology usage. We did not lose any time in questioning and discussion part. Also, we were prepared for the game part therefore we there was not a problem in this part." (FI_G3_CA, RP_2)

Therefore, since the topics they tried to teach were such complex and multidimensional issues that should be covered with argumentation in such a time, a revision was decided to be done in the given times for teaching performances. As PSTs requested in the first implementation, teaching performances were extended into two weeks. PSTs were decided to be given one and a half hour in total. In the first week, they had a half hour and in the consecutive week, they had an hour to implement their activities.

3.6.3.1.4. Revisions in TPACK-Reflection stage

PSTs were also asked about the effectiveness of reflection paper writing on their development of effective SSI teaching practices with technology. Most of them stated that writing reflection made them think about the effectiveness of their performance and analyze their strengths and weaknesses. According to their statements, reflection papers were effective tools to help PSTs criticize their performances.

> "While writing reflections, I had chance to critique myself. When I turn back, I can see in which points I made mistakes or what the reasons of these mistakes are." (FI_G4_EG, RP_3)

> "I can see my strengths and weakness about the concept. It is somehow a self-criticism." (FI_G5_DC, RP_3)

> "We wrote our reflection papers by using the reflection paper questions. While answering those questions, we need to think deeply. It helped to examine and see my weaknesses." (FI_G3_CAD, RP_3)

By writing reflection, they had chance to evaluate their own understanding about effective SSI teaching. The questions asked in the reflection papers let them think about their own thinking critically.

> "I like to write reflections. It shows us how much we improved our understanding or it shows whether we have misunderstanding or not. For example, before I write my reflection paper III, I checked my reflection paper I. It was really fun for me because I realized that before the lesson, I did really not know about TPACK." (FI_G6_BY, RP_3)

> "When I was answering questions sometimes I face with questions that I never ask myself and I need to think more. At the beginning this disturb me very much because it is new, but then I can adapt and improve myself in thinking about my learning process." (FI_G7_FB, RP_3)

PSTs stated that analyzing their performance and answering the reflection paper questions activated them to think about the ways to develop their SSI teaching with technology knowledge.

> "The most important teaching tool was reflections because with critical thinking I review what I did or did not. Moreover, with reflections I think about how I can improve myself in terms of TPACK." (FI_G1_MK, RP_3)

When the effectiveness of reflections on their development of effective SSI teaching with technology were asked, although they acknowledged the importance of them in terms of being aware of their own strengths and weaknesses and their progress, they complained about the redundancy of the questions asked in the reflection papers. They especially complained about the second reflection paper. Due to excessive numbers of questions asked in the second reflection paper, PSTs thought that it was not effective and even waste of time.

> "Reflection papers did not help me at all during this process. I spent hours to my second reflection paper and all I did was to answer same questions. I think, they should be simpler in order to help my progress." (FI_G7_ÖK, RP_3)

Considering the potential of reflections in activating PSTs to think about their development of SSI teaching practices with technology, they were regarded as an indispensable element of the course. On the other hand, PSTs felt smothered in questions and this situation affected their motivation to reflect on their practices. Therefore, to overcome this issue we decided to do some revisions in reflections. First of all, we decided to simplify the second reflection paper by reducing the number of questions substantially. However, there are important questions to be asked to PSTs to help them evaluate their practice in terms of SSI teaching and technology integration. Therefore, those questions were decided to be asked to the volunteer PSTs in interviews.

PSTs admired the contribution of video recordings of the teaching performances to their reflection. They stated that with the help of the recordings they had chance to evaluate both their and other groups' performances.

> "After teaching performance, we had a chance to watch our performance in a video. So, the video helped us to see our shortcomings and we have identified the parts that we need to improve ourselves". (FI_G6_RO, RP_3)

To increase the potential of video recordings in reflection, a revision was decided to be done in further implementations. Each PSTs were expected to write comments to the videos of each groups' teaching performances as it was explained above.

Therefore, PSTs were asked to watch each group's performances to reflect on their weaknesses and strengths deeply.

3.2.3.2. *The last prototype of the re-designed course*

The revision plans mentioned above were discussed with dissertation examining committee and the last prototype of the course was decided together. The revised last prototype of the course included again five stages. This prototype was implemented in 2015-2016 Fall semester for the second time. The activities and assignments that are different from the previous prototypes were explained below in detail.

First Stage: TPACK Comprehension

The first stage of the course was decided to be enlarged to overcome PSTs difficulties in SSI topic selection. Therefore, this stage lasted longer. All the readings about SSI, TPACK and metacognition were given and discussed before passing to the next stage.

Differently from the previous prototype, in the fifth week of this stage, PSTs were given certain time in the course hour to start discussions about their group lesson plans. Until this week, class discussion was held about all of the readings covering SSI. Therefore, at the end of the fifth week, they were expected to have a clear view about the nature and characteristics of an SSI topic. Therefore, they were asked to discuss and decide different SSI topics related to the science curriculum based on their previous knowledge or personal experiences. While discussing, they had chance to ask help from the instructors. At the end of this group discussion, some of the groups decided their SSI topics to be covered in their lesson plans and teaching performances. Other groups continued their discussions about SSI topic selection in their Wiki page.

Second Stage: Observation of Instruction

In this stage, a guest teacher was invited to deliver a speech about his experiences with technology. The teacher was quite experienced in technology use for educational purposes. He was previously a teacher in training center. He mentioned that thanks to his interest in technology, he was very successful in his profession. He has knowledge in variety of technological tools. For example, he wrote a practice book for his students by increasing his knowledge on technologies related to book writing. He also learned to prepare simulations by using different software. He also mentioned that, in his current school, he is an active user of educational social media. He stated that he always shares different news or videos about socioscientific issues through these social media. Consequently, he provided different examples to technology integration in both classroom activities and out-of school activities. His experiences excited PSTs' attention. They asked many questions to learn more about his experiences.

After the guest teachers' talk, teaching assistant performed a sample teaching. As it was mentioned before, the content of the sample teaching was different from the one performed in the first implementation. The number and variety of the technological tools was increased so that PSTs' observations of technology integration into SSI teaching were enriched.

In this stage, PSTs were again given time to make discussions about their lesson plans. Therefore, in addition to the discussion held in Wiki pages, they had chance to be involved in face-to-face discussions about their lesson plan preparation.

Third Stage: Practice of Instruction

This was the longest stage in the course. Groups started to prepare their lesson plans in the fifth week. Then, their teaching performances started from the eighth week and lasted for seven weeks. Therefore, they practiced technology integration into SSI teaching through planning and teaching almost throughout the semester.

The time devoted to groups' performances were increased compared to the first implementation. PSTs were expected to perform their teaching in two weeks. In the first week of their performance, they were expected to make an entrance to their teaching performance, called 'initiation of teaching'. They were allowed to give lecture about their topic in which the arguments on the issue were explained. One of the groups arranged a skype talk with a guest scientist to get information about the topic. Some of the groups prepared a video or animation in which they explained the arguments from different perspectives. Some of them only prepared a presentation. In the following week of their first performance, they were expected to implement their activities to teach SSI topic.

Fourth Stage: Reflection of TPACK

All of the PSTs were expected to write a reflection paper after their group performance. Moreover, they were asked to reflect on other groups' performances by writing comments to their teaching videos. PSTs were expected to write two reflection papers and eight video comments in total. There were some differences in the contents of the reflection paper as it was explained in the revisions in this stage.

Fifth Stage: Revision of TPACK

There was no change in this stage. As in the first implementation, PSTs were expected to prepare another lesson plan individually. With reflections and video comments, they were asked to think about their weaknesses in previous stages and revise them in their individual lesson plans.

3.6.4. Cycle 6: Implementation of the last prototype

In the previous cycle, revisions were decided to be done on the second prototype by considering the results of the data collected in the first implementation, personal experience gained in the first implementation and expert reviews provided by dissertation examining committee. Then, the third prototype was developed. In the sixth cycle, the third prototype was implemented. In this second implementation, again data was collected via different data collection tools including lesson plans, reflection papers and interviews.

3.7. Limitations and Delimitations of the Study

Limitations of a study includes the potential weakness caused from the analysis, the nature of the instruments or the sample; that is, the threats to internal validity to be avoided or minimized (Pajares, 2007). This study had also some limitations and the researcher tried to minimize them. In this dissertation, PSTs were asked to prepare lesson plans and reflection papers to be able to reveal their development of effective SSI teaching practices with technology and their metacognition. However, since all of the TPACK components were tried to be reflected on the parts of the lesson plans, some of the prompting questions was tended to be omitted. In order to encourage PSTs to consider those questions, they were prompted through Wiki comment pages.

Moreover, since different aspects of metacognition and TPACK for effective SSI teaching was tried to be revealed from reflection papers, there were detailed prompting questions that PSTs were expected to consider. Especially, the prompting questions of reflection paper-2 were formed to include different aspects of metacognition; thus, it was relatively lengthy. When we realized that PSTs felt frustrated in completing the reflection papers, the questions were simplified and some parts of the reflection paper were lessened by upholding the content validity of the instrument.

Another limitation of the study was the language PSTs were expected to use in the course. Since the language of instruction at the university is English, PSTs were expected to speak and write in English, although they are not native English speakers. Therefore, they could not express what they want to say in the teaching performances. Moreover, due to the difficulty in expression, PSTs might not reflect their exact thoughts in the reflection papers. In order to prevent the misleading data, unclear statements in the written assignments were clarified by asking PSTs what they intended to say.

Delimitation of a study defines the scope and boundaries of the study. It includes what the researcher not doing and why to choose not to do those (Pajares, 2007). This study aimed to re-design one-semester undergraduate course to develop PSTs' effective SSI teaching practices with technology by activating metacognition. The course was delimited to one semester. Broader restructuring of the program for this purpose may yield fruitful result, but it was aimed to re-design an already existing course to make it manageable in the scope of a dissertation study.

In this study, the development of PSTs' effective SSI teaching with technology was studied in only one university. Implementing the designed solution in different universities may result in differences. However, this study aimed to develop usable knowledge or theory that serves *local* practice (Barab & Squire, 2004; McKenney & Reeves, 2014). Although the solution was local, as one of the two-fold yield of the EDR studies, it was tried to produce design principles to guide further design attempts in other contexts.

3.8. Trustworthiness of Qualitative Data

The quality of the qualitative research is distinguished with different criteria from those used in traditional social science (Patton, 2002). To meet the demand for different criteria for evaluating the rigor in qualitative research, Lincoln and Guba (1986) proposed "credibility as an analog to internal validity, transferability as an analog to external validity, dependability as an analog to reliability, and conformability as an analog to objectivity" (p. 76-77). They referred to all these criteria as criteria of *trustworthiness* as a term parallel to rigor.

In order to ensure trustworthiness of the qualitative studies, Creswell (2007) recommended eight frequently used strategies, namely, prolonged engagement and persistent observation, triangulation, peer review or debriefing, negative case analysis, clarifying researcher bias, member checking, rich and thick description, and external consultant. Moreover, the researcher recommended that the qualitative researchers should engage in at least two of them.

Although this EDR study aimed to produce a solution to a local problem, as Merriam (1998) stated "general resides in the particular, that we can extract a universal from a particular" (p. 210) through different strategies. To increase the extent to which the findings of a study can be applied to other situations, which is called external validity or generalizability, researchers recommended providing *thick description* of the research situation, so that other researchers can decide how much their situation coincides with the explained research situation (Lincoln & Guba, 1985; Merriam, 1998).

McKenney and Reeves (2012) emphasized the importance of careful consideration of the variability across the context. Therefore, they urged the producers of theoretical and practical contributions via EDR to describe the specific characteristics of both the intervention and the context in which it is implemented. Moreover, McKenney et al. (2006) suggested the researchers who conduct EDR to portray the local contextual factors like school climate, pupil population or resources as well as system level contextual factors like large-scale examination to allow the translation of potential insight gained in an EDR to other settings. Besides, McKenney and Reeves (2012) asserted that the responsibility of generalization of the EDR studies could be seen as two-sided as in other genres of research. Although the researcher needs to provide thick description of the context being studied, it is the responsibility of the consumer to make the transfer to other specific context when putting the outputs of the design research to use.

In this study, I reported the whole process of designing and implementing the re-designed undergraduate course as extensive and detailed as possible to allow the readers and researchers to get the theoretical and practical insights easily. However, other researchers may interpret and put into practice the outputs of this study differently due to the differences in their experiences.

Another strategy to increase the trustworthiness of the study was *triangulation*. Triangulation means using multiple different sources of data, investigator, or methods to confirm the findings and provide corroborating evidence (Creswell, 2007; Merriam, 1998; Yin, 2010). For this purpose, I used different data sources. Lesson plans, video-recordings, interviews and student artifacts were used to diversify the data collection methods to overcome the limitations of each data collection methods. Moreover, in data analysis, different researchers coded the data. Researchers who had experiences in the field of metacognition and TPACK coded a portion of the data.

Prolonged engagement and persistent observation in the field is another validation strategy (Cresswell, 2007; Miles & Huberman, 1994) in order to help researchers make decisions about what is salient to the study, relevant to the purpose of the study. It was also recommended to build trust with participants to learn the culture. In addition to being the researcher, I was also the research assistant of the re-designed course. Therefore, I developed rapport and built trust with the participants. We built a good relationship with participants. They kept the contact even after the study to take advice for their future career choices. Therefore, they were as transparent as possible in interviews. They even made confessions in VSRIs about some of the tricks they did in their teaching performances. That is, they were honest in their answers thanks to the rapport developed throughout the semester.

3.9. Ethical Issues

Prior to starting the implementations, ethics approval was granted from the Ethical Committee of the university (see Appendix E). Participants were asked to give informed and voluntary consent before participating in this study. They were declared that they have opportunity to withdraw at any time during the data collection period with all data pertaining to them being deleted and not used in the study. Although they were expected to fulfill the course requirements to pass the course, they were asked for their voluntariness to let the researcher use the assignments and activities completed in the scope of the course for the purpose of dissertation. Moreover, all the interviews were conducted only with volunteer participants.

In the first week, the course outline was explained to the participants. They were informed that they are expected to prepare lesson plans and perform them in the classroom. They were negotiated for recording these performances and sharing the video-records of their performances with their classmates. Researcher ensured that confidentiality of data –video recordings, voice recordings and other written assignments- would be protected, and the names of the participants would not be reported anywhere. All participants were given pseudonyms to be mentioned throughout the dissertation. I did not use any identifiable student data in reporting.

3.10. Summary

In this chapter, firstly, the research paradigm of the study was explained. Then, the research design with characteristic features of it was explicated. Afterwards, the data collection methods and data analysis procedures were detailed. Then, design of the course and the processes followed in re-designing the course was explained. Then, the strategies to ensure research rigor was explained by elucidating the trustworthiness of qualitative data. Limitations and delimitations of the dissertation were defined to manifest the condition that could be controlled and could not be controlled. Lastly, the ethical issues considered in the scope of this dissertation were asserted.

CHAPTER 4

DEVELOPMENT OF PRESERVICE SCIENCE TEACHERS' EFFECTIVE SSI TEACHING PRACTICES WITH TECHNOLOGY

The main purpose of the re-designed course was to develop PSTs' effective SSI teaching practices with technology. In order to decide the effectiveness of the course in reaching the purpose of developing effective SSI teaching practices, their developments were tracked with different data collection tools throughout the semester.

As the main purpose of this study, the development in their SSI teaching practices with technology was elucidated in this chapter. Therefore, the following research question with subsidiary questions was answered in this chapter. While the first, second and last subsidiary research questions were tried to be answered in this chapter, the third and fourth subsidiary questions were answered in the following chapter.

5. How effective is the re-designed course in developing pre-service science teachers' effective SSI teaching practices with technology by activating metacognition?
    a. What is the development of PSTs' effective SSI teaching practices throughout the course?
    b. What is the nature of PSTs' SSI teaching practices after they attended to the re-designed course?
    c. What is the pattern of PSTs' metacognition underlying their SSI teaching practices with technology?
    d. What is the relationship between the PSTs' effective SSI teaching practices with technology and metacognition patterns?
    e. What is the contribution of the re-designed course in the development of PSTs' effective SSI teaching practices?

There were different issues influencing the effectiveness of PSTs' SSI teaching practices with technology. these issues were: (a) case-based issues, (b) classroom discourse issues, (c) nature of science issues and (d) cultural issues. In this chapter, these issues were explained in detail separately.

4.1. Case-based Issues

In this section, PSTs' selection of SSI topics and the issues related to the cases they faced during teaching were articulated. PSTs' topic selection can be related to their knowledge of curriculum, because they selected SSI topics to reach the curricular goals.

PSTs were expected to write which curricular objectives they were planning to reach with the planned lesson. They were prompted to write objectives from each of the four learning areas of the curriculum, which are knowledge, skills, affect, and STSE. These learning areas were operationalized in the current Turkish science curriculum as in Figure 10.

Knowledge	Skill	Affect	Science-Technology-Society-Environment
a. Life and living beings b. Matter and change c. Physical processes d. The Earth and the Universe	a. Science process skills b. Life skills ➢ Analytical thinking ➢ Decision making ➢ Creative thinking ➢ Entrepreneurship ➢ Communication ➢ Team work	a. Attitude b. Motivation c. Values d. Responsibility	a. Socio-scientific issues b. Nature of Science c. Science and Technology relationship d. Social contribution of science e. Awareness of Sustainable Development f. Awareness about Science and Career

Figure 10. Learning areas of Turkish science curriculum (MoNE, 2013, p.1)

In addition to the PSTs' curriculum knowledge, there are some case-based issues influencing the effectiveness of their SSI teaching. Firstly, the selected SSI case should have some properties. Students should have true life experience about the selected SSI. The complexity of the selected SSI topics' scientific background should be appropriate for students' understanding. Moreover, the selected SSI topic should convenient for developing care and empathy. Then, the selected SSI topic should be as much specific as possible so that the students' can handle forming their claims and finding evidences. In addition to the criteria of SSI topics selection that PSTs used, their knowledge about the SSI topic can also be influential in the effectiveness of SSI teaching. Teacher should know all the arguments from different perspective about their selected SSI topic. By this way, PSTs could easily manage classroom discourse, show multi-perspective nature of the SSI, and decide what to assess about students' learning. The case-based issues that are influential in SSI teaching were summarized in Table 12.

Table 12.
Case-Based Issues Influencing the Effectiveness of SSI Teaching

Categories	Codes	Explanation
SSI topic selection	Life experiences	Students should have true life experience about the selected SSI
	Scientific background	The complexity of the selected SSI topics' scientific background should be appropriate for students' understanding
	Care and empathy	The selected SSI topic should convenient for developing care and empathy
	Specificity	The selected SSI topic should be as much specific as possible so that the students' can handle forming their claims and finding evidences
SSI topic knowledge		Teacher should know all the arguments from different perspective about their selected SSI topic.

In the following sections, these issues were explicated based on individual and group lesson plans and teaching performances of groups.

4.1.1. SSI topic selection

Before starting to planning process, all of the PSTs were guided to examine the Turkish science curriculum from SSI teaching perspective. Then, they decided to cover a certain topic in the curriculum with a related socioscientific issue. Majority of the groups (n=10) selected a topic from 8th grade for their groups lesson plans. Three of the groups selected a topic from 5th grade level, two of them selected topic from 6th grade level and one of the groups selected a topic from 7th grade.

There are varieties of SSI topics covered in group lesson plans and individual lesson plans as listed in Table 13. Among the group lesson plans, about half of the groups (n=7) selected topics related to biotechnology like genetically modified organisms (n_{FI}=1; n_{SI}=1), human cloning (n_{FI}=1; n_{SI}=1), gene therapy (n_{FI}=1; n_{SI}=1), vaccination (n_{FI}=1; n_{SI}=1), pesticides and chemical fertilizers (n_{SI}=1), and animal testing (n_{SI}=1). Moreover, some of the groups selected topic about the energy resources like construction of hydroelectrical santral (n_{SI}=1) and use of alternative energy sources (n_{FI}=1). Some of the groups also selected topics related to environmental issues like global climate change (n_{FI}=1) and construction of a road on Black Sea Region (n_{SI}=1).

On the other hand, two of the groups from the first implementation could not select a proper SSI topic. One of them planned to cover only a science topic, carbon cycle. The other group selected an environmental problem, water pollution, as the topic. Neither of these two topics had the characteristics of SSI topics. Based upon the observation of the difficulty of students' SSI selection in the first implementation, the syllabus of the course was revised. The timing of the readings were changed in the second implementation to help PSTs to understand the SSI theoretically, then observe the implementation of it in a sample teaching and then practice teaching by planning and teaching, in this order. Therefore, the changes in the design of the course about the ordering of the activities might be influential that PSTs in the second implementation were better at determining an SSI topic by considering the arguments about the issue from multiple perspectives.

PSTs' SSI topic selection also showed variety in their individual lesson plans. In the first implementation, majority of the PSTs (n=25) selected an SSI from eighth grade while there are also PSTs planned to cover a topic from seventh grade (n=8), sixth grade (n=1) and fifth grade (n=1). Therefore, there was not a variety in their SSI topic selection. Almost all of the PSTs in the first implementation (n=25) planned to cover an SSI topic related to genetics/biotechnology field. Only 3 PSTs selected the issues related to the energy sources and 4 PSTs selected issues concerning the environmental problems like overpopulation, waste disposal etc. One of the PSTs in the first implementation selected using orphans as cadaver as SSI topic; however, the PST addresses it as only an ethical issue rather than an SSI. Similarly, one of the PSTs addressed overpopulation in the individual lesson plans as an environmental issue rather than an SSI.

Table 13
Selected Socioscientific Issues about Different Learning Areas

Learning areas	SSI topics	GLPs		ILPs		Total
		FI	SI	FI	SI	
Life and living beings	Genetically modified foods	1	1	9	-	11
	Gene cloning	-	-	6	-	6
	Organ and tissue donation	-	-	2	4	6
	Animal testing	-	1	4	-	5
	Gene therapy	1	1	1	1	4
	Vaccination	1	1	1	-	3
	Food additives	-	-	1	2	3
	Stem cells	-	-	-	3	3
	Antibiotic and diatery pill use	-	-	-	3	3
	Human cloning	1	1	-	-	2
	Human genome project	-	-	-	2	2
	Pecticides and chemical fertilizers	-	1	-	-	1
	Huntington disease	-	-	-	1	1
The Earth and the Universe	Climate change	1	-	1	-	2
	Oil drilling	-	-	-	2	2
	Road production	-	1	-	-	1
	Fish farming	-	-	-	1	1
	Waste disposal	-	-	1	-	1
	Wetlands	-	-	1	-	1
Physical processes	Nuclear energy	-	-	1	19	20
	Renewable energy	1	-	-	1	2
	HES	-	1	1	-	2
	Biofuels	-	-	-	1	1
Total		6	8	29	40	83

There was more variation in SSI topic selection of PSTs in the second implementation. 14 PSTs selected an SSI topic from the 8th grade, 17 PSTs selected from 7th grade, 6 PSTs selected from the 6th grade and 3 PSTs selected from the 5th grade. While 21 PSTs in the second implementation planned to cover an SSI topic related to energy resources, 16 PSTs selected an issue related to genetics/ biotechnology field and 3 PSTs selected an issue about environmental problems like fish farming, oil drilling etc. One of the PSTs in the second implementation addresses abortion as an ethical issue and two of them addressed protecting animals from extinction and overpopulation as environmental issues rather than SSI topics.

The details of the selected SSI topics were given in Table 13 for both implementations. Some of the PSTs mentioned their SSI topic selection for group lesson plans in their reflection papers and interviews. Some of the groups tried to select SSI topic to make students grasp the importance of the issue for their own life easily. Therefore, they tried to select SSI topics relevant and meaningful to learn for their target students. To be able to select relevant and meaningful SSI topics, groups focused on different criteria. They selected the topics because students had experience with the related SSI topic. Another criterion stated by PSTs was that the topic did not include scientific background including complex concepts and processes allowing understanding of the SSI. Moreover, they selected the topic, due to the possibility of developing empathy.

4.1.1.1. Life experiences

To be able to select relevant and meaningful SSI topics to teach and learn, PSTs considered the closeness of the topic to students' daily life. They tried to select topics that students have true life experiences. They stated that if they selected SSI topic familiar to students, students can easily engage in discussion and be willing to learn about the SSI.

For this criterion in mind, some of the groups selected vaccination, because every student had experience with vaccination. Until elementary grade, they had to be vaccinated many times. They were informed about the effects of vaccination on their health. Since students had experience on the issue, they may value the importance of the topic for their own life. Thus, PSTs thought that students could easily participate in the discussions.

> "We chose really good topic, because they all were vaccinated before, they got sick before, and they may have heard news about vaccination. Moreover, their families have information about it-biased or not-. So even without websites, most of the students have something to say about vaccination." (FI_G7_BB, RP_2)"

> "Their daily life experiences are enough, they were vaccinated before." (FI_G7_BB, RP_2)

In their teaching performances, they also realized the contribution of students' life experiences on their decisions. They stated that if students had real life experiences about the issue, they could easily understand the topic and find evidences.

> "I think students living in that region understand the case better and find evidences easily. Because their relative might have such experiences. They might also have more personal experience. Therefore, their life experiences contributed to their point of views." (SI_G6_MCO, PTSI)

The first group of the second implementation selected hydroelectric santral (HES) construction for their teaching performance. They realized that students who had real life experience considered different aspects of HES construction and leaded the discussion.

> "CU: This groups' discussion performance was really good.
> DCI: One of them was from Black Sea region and had many real life experiences about HES construction.
> CU: Three of the students in that group were from HES region. They constructed arguments from an unexpected perspective. They were eager to find evidences to support their claim. At the beginning, we did not want to discuss from that perspective. However, they persuaded us for their claims with convincing evidences." (SI_G1, VSRI)

Their experiences and observation about the role of students' life experiences about SSI on their engagement urged them to select more relevant SSI topics in their individual lesson plans. The most frequently selected SSI topic was nuclear power plant construction in individual lesson plans.Twenty PSTs in total decided to cover nuclear power plant construction in their lessons. They stated that they selected this issue, since it is a controversial issue in Turkey due to the planned nuclear power plants in different locations of the country.

> "Teacher tries to reach the objectives through the socio-scientific issue Akkuyu nuclear power plant construction in Mersin. This power plant is planned to establish in order to supply electric energy to our country. However, people think differently about this power plant. Some of them believe that it damages the natural beauty of this region; some of them believe that it solves the energy crisis and dependency on foreign countries. In this point of view, there are totally three main roles that students play which are economist and environmentalist. With the lights of these roles, students will make argumentation related to Akkuyu nuclear power plant. They will discuss both positive and negative effects

> of this power plant and decide whether it is appropriate to be established in our country or not. Finally, they will reach an agreement whether the power plant is established or not.” (SI_G6_MO, ILP)

Since there were many current news and magazines about nuclear power plants, students had opportunity to read, watch and listen different arguments related to nuclear power plants. Therefore, by selecting nuclear power plant construction as an SSI to cover in their lessons, PSTs aimed to increase their students’ scientific literacy. By this way, students could engage in social debate as informed citizens about the issue in their daily life.

The SSI topics selected by PSTs related to environmental problems were global warming, overpopulation, waste disposal, wetlands, oil drilling, fish farming and being vegetarian. Explanations of some of the SSI topics as retrieved from the lesson plans were given below.

> “The socio scientific issue is ‘Should fish farming be banned or not?’ Fish farming is important source for obtaining fish. It is obvious that the wild fishes are not enough for the growing world population. On the other hand, Baits used on the farms caused sea pollution. The crowded fish population in cages causing various diseases at fish and it affect wild fish.” (SI_G1_EC, ILP)

> “The socio scientific issue is “Should the wetland in Lake Eymir be dried or not.” Wetlands are low-lying areas where water is always at or just below the surface. Types of wetlands include rivers, streams and swamps. Wetlands have very benefits such as they stop flooding in the areas surrounding the wetland and additionally they filter the unwanted solute and prevent surface water from pollution. They are also important for biodiversity because hosts many kinds of organisms, animals, plants and microorganisms. On the other hand, it gives worst odor and cause growing some unwanted animals and insects such as mosquito. That’s why people who live close to wetland can suffer from unwanted reasons and they may strongly want to dry it.” (FI_G7_FB, ILP)

While deciding the environmental issues as SSI topic, they generally considered the proximity of the environmental issue. As it can be seen in the quotation, one of them selected fish farming which can be considered as an issue concerning our country whose three borderlines are surrounded by seawaters. Moreover, Lake Eymir is located within the borders of the campus, so the PSTs decided to teach issues related to the lake that has possibility to affect their life also.

To conclude, the groups, who selected SSI topic about which students had real life experiences, observed the positive effect of the selected topic on students' engagement in classroom discourse. For this reason, more PSTs selected topical issues like nuclear power plant construction and genetically modified foods. Since there different nuclear power plant construction plan in different locations of the country and all of the people were exposed to genetically modified foods in their daily diets, there was a high probability of students' having real life experiences about these issues.

4.1.1.2. Scientific background

The other criterion of the groups in selecting SSI topic was understandability of the scientific background of the SI topics. Groups also thought that the scientific background of the issue should also be appropriate so that students can easily understand the topic. As in the following quotations, one of the groups in the first implementation decided to cover vaccination issue. They stated that since students have necessary background knowledge about blood cells and immune system, students can easily understand the scientific claims and evidences related to the issue.

> "Their scientific knowledge is enough about the topic, because they already learned blood cells, especially white blood cells which are responsible for protection our body. Their daily life experiences are enough again we mentioned, they were vaccinated before, they got sick before, and they may have heard news about vaccination." (FI_G7_BB, RP_2)

> "Now students have scientific information about vaccination. Therefore, they can easily understand the evidences related to the issue." (FI_G7_OK, RP_2)

Moreover, the group who decided to address road construction on Black Sea Region gave rationale for their SSI selection that the SSI topic does not require complex scientific background that students could not understand. Therefore, their SSI topic was quite appropriate for students to discuss.

> "OU: The topic selection is important. The topic is so attractive; it is from students' daily life. We did not select the topics like gene therapy.

> Most of us have limited knowledge about those topics so it becomes boring to participate. Students may say I do not understand, therefore they may not listen the lesson." (SI_G6_OU, VSRI)

Some of the groups stated that they had difficulty in deciding the SSI topic, due to their concerns about the complexity of the scientific background of the SSI. In order to decide the appropriateness of the issue to students' level, they stated that they selected topic involved in curriculum. They selected topics like genetically modified foods or alternative energy sources, since these issues are included in the curriculum.

> "This issue is proper for 8th grade students because it is included in curriculum. This issue was taught after they learned 'what is energy' unit so they relate the issue to the energy topic." (FI_G8_AD, RP_2)

The groups performed their plans about SSI teaching and observed other groups' teaching performances. Based on their experiences in these performances, they reached the same conclusion that if the SSI topic was too difficult and complex to understand, they had difficulty in teaching and learning SSI.

The groups who performed argumentation in their teaching effectively stated that the reason of their success could be about their selection of appropriate SSI topic for students' levels to understand the scientific knowledge related to SSI. They thought that the selected topic should not require understanding of complex scientific information. Since their topic was simple and clear, they were able to teach effectively.

> "SI_G6_OU: Of course, there is a big impact of the topic on our effectiveness. The topic was so attractive. It is from daily life. We did not address a topic like gene therapy. I think most of us had limited knowledge about that topic, so it was boring. Students may say that I do not understand and may not listen the lesson.
> SI_G6_DT: I even have doubts about whether such kind of topics can be addressed as SSI topic in this grade level.
> SI_G6_OU: In elementary level, cloning or gene therapy may be too difficult to address." (SI_VSRI_ G6)

Another group who performed effective SSI teaching also attributed their effectiveness in the topic selection. Group members stated that when other groups' SSI required discussions about complex scientific concepts, they had difficulty in following discussions. They had opportunity to observe six teaching performance until their teaching performance. Therefore, they considered the difficulty level of the scientific data used for evidences.

> "RA: I had difficulty in understanding the topic in some of the groups' teaching performances. I confused with the concepts and could not understand the evidences. I thought that elementary school children cannot understand these evidences. Therefore, we tried to explain the issue in an understandable way for elementary grade students." (SI_G7, VSRI)

In order to decide the appropriateness of the scientific knowledge inherent in SSI topic for students' understanding, PSTs should have necessary knowledge of students understanding, thinking and learning. Therefore, PSTs decided the students' prior knowledge and misconceptions that may interfere with students' understanding of the scientific background of the SSI. PSTs' planned to use different strategies and technologies to determine and deal with the students' prior knowledge and misconceptions related to the SSI.

All of the groups mentioned the misconceptions that may affect students' learning of the SSI topic. Some of the examples about PSTs' knowledge about students' possible misconceptions was given below.

> "According to American Association for the Advancement of Science people and also students think that genetically modified organisms are not safe for human health. Also, this is a very common misconception all over the world. Contrary to popular misconceptions, GM crops are the most extensively tested crops ever added to our food supply. GM and non-GM potatoes, soy, rice and corn are nutritionally equivalent.(AAAS, 2012).In addition, GM foods currently traded on the international market have passed risk assessments in several countries and are not likely to present risks for human health. (WHO, 2005)." (FI_G2, GLP)

> "The second misconception is that they (renewable energy sources) never produce any pollution when we use them." (FI_G8, GLP)

> "The vaccine will be effective after becoming sick. Vaccines have hundred percent protections against diseases. Students believe that people won't become sick when they are vaccinated." (SI_G2, GLP)

> "The first possible misconception is that students think the clone's age and human's age are same. The second one is that clones are identical to original. The clones are not identical to the original. They are only

> identical genetically. The environment also has importance to determine phenotype. In addition students have confusion about this question which is: 'Are twins different from clones or are they the same at the genetic level?'." (SI_G8, GLP)

Only five groups in total mentioned their plan to elicit students' misconceptions. They planned to figure out students' misconceptions mostly by questioning.

> "When she ask the question 'Do you think animals research work on humans or not?'. If there any misconception occurs, teacher notice that and then eliminate. (SI_G7, GLP)

Another group planned to elicit students' misconceptions through video at the beginning of the lesson.

> "We ask students questions about the topic. Then we show them a video about the lesson. Then we try to elicit their misconceptions about the topic." (FI_G1, GLP)

Differently, one group planned to elicit students' misconceptions through the discussions held in argumentation activity, rather than eliciting at the beginning of the lesson and handling before the activities.

> "During argumentation, they will share their ideas, pros, counters. At this point, we will detect both prior knowledge and misconceptions. Since we will observe and pursue each group during argumentation." (SI_G8, GLP)

PSTs did not have a systematic approach to overcome the misconception they elicited in students' mind. They mostly planned to deal with misconceptions just telling the truths and giving examples to students.

> "We will give specific examples which are taken from scientific articles to reduce the causes of misconception in students' mind." (FI_G2, GLP)

> "We will focus on the last misconception in our lesson plan we will use slides to show steps both for twin and clone." (SI_G8, GLP)

Moreover, similar to their strategy to elicit it, PSTs planned to use animation, simulation or video in order to help them overcome students' misconceptions.

Regarding the prior knowledge students possess, all of the groups, except two groups from the second implementation, had awareness. Since they were not teachers in real classroom and did not have chance to know their students based on the data they gathered, they mostly referred to the previous curriculum objectives about the topic. They were able to analyze the curriculum to find the related objectives indicating what student were expected to know in each grade level.

> "Students learned reproduction, growth and development of Livings/ From seed to sapling in Unit: 5 of 6th grade and human and environment/ Biodiversity in Unit 5 of 7th grade." (FI_G1, GLP)

One of the groups even explained how prior knowledge students were expected to know would affect their further learning in their lesson.

> "At 3rd grade level in 3.6.2 Electric Welding, students learned city electricity which is electric welding. Also, students learned that electricity is limited and costly. Because of this, students paid attention to electricity should be used sparingly.
>
> At 4th grade level in 4.5.2 Relationship between Human and Environment, students realized importance of relationship between human and environment. Moreover, students paid attention to environment pollution (When hydroelectric power plants are thought, their effects on environment is touched on).
>
> At 5th grade level in 5.5.2 Relationship between Human and Environment, students investigated the environmental problems as a result of human activities and they made suggestions for the solution of these problems. Therefore, they notice effects of hydroelectric power plants on environment and make inference that these effects are the result of human activities.
>
> At the 6th grade in 6.6.2 Fuels, students classified as solid, liquid and gaseous fuels and they learned the importance of renewable energy sources. Therefore, students can realize the importance of hydroelectric power plants when teacher show news about this power plant." (SI_G1, GLP)

Congruent with group lesson plans, the groups of both implementations did not have a systematic approach for eliciting and overcoming students' misconceptions in their teaching performances. Although all of the groups determined the possible misconceptions about the issue, they were not able to make plan to elicit and overcome them. Therefore, they did not do anything about this in their teaching performances.

About eliciting the prior knowledge that student have, congruent with their group lesson plans, the groups in the first implementation mainly relied on questioning to elicit student ideas. They asked students whether they know or not the concepts related to the issue. For example, the first group devoted a lot of time for questioning. Almost all of the groups did questioning before starting to explain the issue. However, most of the groups were not effective in asking quality questions to elicit students' ideas. Moreover, they did not consider students' answers to make decisions for the rest of the lesson contrary to their statements in the group lesson plans. Only few groups effectively evaluated the students' answers and responded them accordingly. When they were asking questions, if they realized any lack of knowledge or wrong conceptions, they tried to remediate these by explaining the scientific truths.

> "Teacher: Did you read or see anything related to climate change on the internet, newspapers or else?
> Student: Yes, I read the news and scientists say that climate get warmer globally.
> Teacher: Yes. But a little while ago I said this is wrong. Not only warm but also can get colder. You should be careful about the reliability of the resources because they can misdirect us. Okey. What are the reasons of climate change? What do you think about the reasons of climate change?
> Student 2: There are many cars. So exhaust of cars can be reason.
> Teacher: Yes, okey. And what else? Gülşah?" (Teaching performance of Group 1 in first implementation, Time: 33:00)

The teacher continued to ask questions about the reasons of the climate change and how these factors affect the climate change. Some of the groups in the first implementation, like fourth group, were not so effective in listening and responding to the students' answers to their questions. They rather preferred to activate students' prior knowledge by reminding the topic with direct instruction without trying to understand what students have already known.

In the second implementation, although two groups mentioned about their questioning plan for eliciting prior knowledge, all of the groups asked questions to understand what their students know about the issue and the scientific knowledge related to the issue. Moreover, although only one group stated that they would apply quiz to the students to elicit their prior knowledge, three of the groups in the second implementation used online quizzes to retrieve students' prior knowledge.

In individual lesson plans, almost all of the PSTs (n=71) clearly determined what kind of prior knowledge students need to learn SSI topic and what they know from previous classes. They analyzed the curriculum in detail to figure out what students learned previously. PSTs determined the background knowledge that has the possibility of contributing to or interfering with students' SSI learning.

> "Students need to use their prior knowledge about photosynthesis and respiration. They have been learnt the importance of photosynthesis and how it occurs at 8th grade. By making this activity they need to use this knowledge in comparison biofuels and fossil fuels that according to have biofuels the plants should be grown and they will make photosynthesis until they die. (8.5.1.2.) Students also learnt the fossil formation and the types of fossils at 5th grade. By using this knowledge, students can classify biofuels and fossil fuels according to their features. (5.7.1.3.) Students learnt that homogenous mixtures can also be called as solution and they know that gases can dissolve in water or other liquids. In this way, students can easily understand how CO_2 can be captured in the ocean and seas after using biofuels. (7.3.3.2.) Students learnt renewable and nonrenewable energy sources at 6th grade and classification of fuels as solid, liquid and gas fuels as well as biofuels and fossil fuels after that students are excepted to use this knowledge by comparing the biofuels and fossil fuels according to their advantages and disadvantages. (6.6.2.2.) Students also learnt how power plants work and produce electric energy at 7th grade. After that, they will be able to understand the activity better and examine the good and the bad sides of using biofuels and fossil fuels. (7.6.2.4.)" (SI_G6_OU, ILP)

After determining the background knowledge that students were expected to have, PSTs made decision about the ways to reveal whether their students possess these knowledge or not. In order to elicit students' prior knowledge, PSTs planned to use different tools like KWHL, quiz, simulation or video. Most of the PSTs (n=38) planned to use questioning to elicit and activate students' prior knowledge.

> "In order to activate students' previous knowledge, teacher asks questions related to these topics. If students do not remember the previous knowledge, she tries to give small hints to recall them." (FI_G2_AK, ILP)

In order to attract students and make the rehearsal easy, PSTs also planned to use different multimedia tools.

> "To activate this knowledge, the teacher asks some questions while showing some pictures of fossils to the students. For example, s/he says that do you remember what it is and their usage area. By asking this question and showing some pictures, students can remember that fossils are found in underground and formed from ancient animals and plants." (SI_G5_RK, ILP)

Ten PSTs planned to remind the necessary background information by summarizing and explaining or showing a video.

> "At the beginning, as a teacher I will try to remind students what they learn last week. 'As you remember from last week, we studied about sensory organs' and I will continue with a question to pass today's topic." (FI_G6_BE, ILP)

> "Examples which are given by teacher will help students to remember background knowledge in daily life or gain new knowledge." (FI_G7_OK, ILP)

> "In order to activate the students' knowledge about the subject, teacher shows a video." (FI_G2_SK, ILP)

Some of the PSTs preferred to make all students active in determining their prior knowledge by using different tools. To learn what each student knows about the topic, five PSTs decided to apply a quiz. Three of them planned to use online interactive quiz.

> "I will remind their prior knowledge via a quiz in kahoot." (SI_G8_HC, ILP)

Moreover, three PSTs planned to help students remember required background knowledge by making students investigate a simulation.

> "In order to elicit students' knowledge about the topic, I will make students to investigate the related simulation given in the online learning environment." (SI_G4_KD, ILP)

Lastly, four of the PSTs planned to use KWHL chart to elicit students' prior knowledge. They planned to ask each student to fill the table individually. By looking at the Know part of the chart students filled in the diagram through the online communication platform, PSTs decided to elicit students' prior knowledge.

> "By doing an activity called as KWL chart, I will try to activate this prior knowledge. In the what we Know part in the KWL, I will expect students to write their prior knowledge that help them to construct a bridge which combine them the prior knowledge they have to the discussing sessions topic that Should we use Nuclear plants as one of the source of generating electricity or not?" (SI_G6_DT, ILP)

Although groups planned to ask questions to the students to elicit their prior knowledge, PSTs found different ways to reach this purpose. They effectively determined the necessary background knowledge students should possess and the ways to elicit them. While doing these, PSTs took the advantage of different technological tools.

Again almost all of the PSTs (n=70) were able to determine the possible misconceptions about the SSI topic that students may have.

> "According to my research from different sources, there are possible misconceptions that students have about gene cloning like: - Cloning is a new technology. - Cloned animals live short lives and suffer from health problems. - Cloning is always an artificial process. - Your genes determine all of your characteristics, and cloned organisms are exact copies of the original. - One set of alleles is responsible for determining each trait, and there are only two different alleles (dominant and recessive) for each gene. - All mutations are harmful. - A dominant trait is the most likely to be found in the population. - Human cloning reduces biological diversity. - People created by cloning would be less ensouled than normal humans, or would be sub-human." (FI_G2_AK, ILP)

Some of the PSTs included the scientific explanation of each misconception in their lesson plans. After determining the misconceptions with the mentioned tools to retrieve prior knowledge, most of the PSTs offered ways to address these misconceptions. Although PSTs mentioned different techniques for this purpose, similar to group lesson plans, most of them (n=37) stated that they will overcome students' misconceptions by telling the truth in their individual lesson plans.

> "After showing animated video teacher use direct instruction method in order to inform students who do not know about it. At this stage if students have misconception related to this sentence, teacher corrects in with the help of direct instruction method." (FI_G1_BK, ILP)

PSTs stated that they would make explanation and give examples to help students learn the scientific truths of the misconceptions.

> "These misconceptions will be fixed one by one by giving examples and explanations." (FI_G7_OK, ILP)

Eight of the PSTs planned to use different multimedia tools like animation, simulation and video to overcome the misconceptions.

> "By showing video, students understand that generating electricity is sometimes harmful for nature; therefore, they overcome their misconceptions." (FI_G1_AA, ILP)

Three PSTs planned to eliminate students' misconceptions in class discussions and argumentation activities as in the following example quotation.

> "If students have misconception like this, it is eliminated during the discussion part and at the end of the lesson." (FI_G1_BK, ILP)

Some of the PSTs (n=6) stated that while students are searching for arguments, they will learn the scientific truths about the misconceptions.

> "When students searching information about GMOs from the internet sites which teacher gave them. They can see there are not many genetically modified seeds." (FI_G3_ GI, ILP)

Five of the PSTs planned to use questioning to both elicit and eliminate misconceptions of students. They reported that if they ask questions to the students related to the misconceptions, they could eliminate these misconceptions without any other explanation or activity.

> "These questions are asked in order to remove students' misconceptions in their mind about the organ donation." (FI_G6_BE, ILP)

Different from the other PSTs and the group lesson plans, three PSTs decided to use concept map as a tool to elicit and eliminate the misconceptions.

> "I can also let them prepare a concept map about biodiversity. This concept map and their answers can show me their possible misconceptions about this topic easily and help them to eliminate these misconceptions." (FI_G5_RD, ILP)

From the above quotations, it can be reached to a conclusion that PSTs included more systematic ways to learn about and activate students' prior knowledge as compared to the group lesson plans. However, this is not the case for eliciting and eliminating misconceptions. Similar to the group lesson plans, PSTs did not go further from questioning technique to reveal misconceptions. Moreover, they mostly prefer to explain the scientific truths directly to the students rather than letting them to construct the correct knowledge by themselves.

To sum up although PSTs analyzed the curriculum to determine the related prior knowledge based on the objectives of previous topic, they generally had difficulty in determining the actual knowledge that students' possess that may contribute to or intervene with their understanding of SSI. Similarly, PSTs had difficulty in eliciting and overcoming students' possible misconceptions that may prevent their understanding of SSI. The groups' who effectively determined and activated students' prior knowledge were also effective in determining the complexity of the scientific background of the selected SSI. Therefore, they were able to decide appropriate SSI topics for the target students so that their knowledge deficiencies or misconceptions did not interfere with their understanding of SSI.

4.1.1.3. Care and empathy

Another reason of PSTs for their SSI topic selection was stated as its possibility of developing care and empathy. The seventh group of the second implementation also selected their topic due to similar concerns. They selected animal testing due to the students' interest on animals as they stated in the interviews. According to these PSTs, since students can easily show empathy and care toward animals, discussing animal testing can be meaningful and relevant for students.

> "SI_G7_RA: We will give this topic to students to discuss. We wanted to select a topic that can arouse their interest." (SI_G7, VSRI)

> "Students like animals. They interact with them in natural environment. Animals are part of their daily life. May be some of them have pets. The idea of testing the medicine they used on their pets may be upsetting. Therefore, they can reject animal testing. On the other hand, their family members may be sick and waiting for a medicine to cure their illnesses.

> Therefore, they may support animal testing for production of effective medicine. We prepared our lesson considering these situations." (SI_G7_IT, PTSI)

The group members of this group also thought that student may develop empathy toward both animals and people suffering from diseases.

> "There is animal love in it. I think animal love would be in the foreground. A children may also think like this. On the other hand, a children or his/her relative may be suffering from a disease. If children is observing that the disease cause pain if pills are not used, they may feel that sorrow. Then, these children may say animals should be used, because people are more valuable than animals." (SI_G7_MK, PTSI)

This group selected animal testing so that they could be more willing to learn biotechnology through engaging in SSI reasoning. They were expected to develop empathy toward patients who were waiting for effective medicines to cure their illness. Moreover, students were also expected to develop care and empathy toward animals to prevent them suffering from experiments related to testing medicines. Since students generally like animals and do not want them suffer from experimenting, they could be easily guided to think about the possible ways of testing medicines. Therefore, they can learn applications of biotechnology eagerly.

This group aimed to develop care and empathy with this SSI. Therefore, in their teaching they also tried to use technology for this purpose.

> "MK: At the beginning, we explained the history of animal testing and the positive effect of it on human being. It was seen that we are showing only the advantages. But when we show them the video indicating how animals suffer, they showed a mercy. This was what we want to do." (SI_G7, VSRI)

In their teaching performance, they observed the positive effect of the selected issue on students' engagement. The students internalized their roles, which are pharmacists, rule makers and scientists, given them for argumentation to resolve the issue.

> "They easily understood the science technology and society relationship and biotechnology. We gave roles of scientists, rule makers and pharmacist to students. Since they developed empathy toward patients and animals, they tried to resolve the issue in a best way for both patients and animals. Therefore, they eagerly searched for evidences and

> engaged in discussions as if they were active participants of the society with those roles." (SI_G7_HK, PTSI)

Although they did not consider this criteria in selecting their SSI topic, the groups who selected SSI topics very close to students' daily life observed the importance of developing care and empathy in their teaching. For example, as it was explained above, the first group of the second implementation addressed construction of HES in their teaching. Some of the students were from HES regions. Therefore, they knew the experiences of people living there. Therefore, since they developed empathy toward the people with low socio economic status living there, they constructed arguments from economical perspective. They focused on the role of HES on providing job opportunity for residuals. According to PSTs' statement, that group was the most effective group in engaging discussion, because they were trying to find solutions for the economic problems of the residuals.

Experiencing the role of the SSI topics that have the possibility of developing care and empathy on students' engagement, PSTs selected their SSI topics considering this in their individual lesson plans. Therefore, they selected topics like organ and tissue donation, animal testing, stem cells, antibiotic and dietary pill use etc. Since these issues include finding solutions for patients' problems, students may easily develop care and empathy toward patients.

4.1.1.4. Specificity

PSTs also thought that the SSI topic should be as much specific as possible so that the students' can handle forming their claims and finding evidences to rebut the counter-arguments. The seventh group of the second implementation thought that they succeeded this; thus, students actively involved in the discussion.

> "SI_G7_IT: I think because the specificity of our topic was useful. For example, we did not select a broad topic like today's topic, human cloning. It was not clear what working area of human cloning we should focus. We selected specifically medicine so that they cannot give up.
> SI_G7_RA: We did not include cosmetics so that they cannot say that beauty is not indispensable. We specifically selected animal testing for medicine because medicine is indispensable." (SI_VSRI_G7)

On the other hand, the first and eighth group in the first implementation criticized themselves in terms of making their SSI topic not specific. Therefore, they thought that since their topic was too general, students could not produce counter-arguments to the claims of the other groups, because there were plenty of arguments.

> "FI_G1_BK: Our topic was too general. We were given two specific claims in the nuclear power plant case and we tried to refute only those claims. I think that was very effective. Our topic was too general. It is okey, it is natural but there are many claims about natural cause of global warming or human made claims are scarce. Since everyone found different arguments, the opposite groups could not find any counter-argument related to other group's argument. We should select more specific topic. May be we could say that you should focus on one of these three arguments." (FI_VSRI_G1)

The group members of the eighth group of the first implementation had difficulty in guiding students to find evidences to refute the counter-arguments. They stated, they always felt need to warn students about this issue to ensure the quality of argumentation.

> "FI_G8_CAY: We lost control while students were collecting data. I needed to repeat frequently that you should find evidences by considering the counter-argument. Generally, they tried to find evidences for the arguments that are not related to each other. I really had difficulty in guiding them to consider counter-arguments." (FI_VSRI_G8)

Therefore, based on their experiences in dealing with classroom discourse in such broad topic, they stated the need for narrowing down the issue as much as possible.

> "If I would teach this SSI again, I would change the scope of the issue. Engaging students in discussion about one specific alternative solution can be more effective. A specific case can be given to students. For example students can be asked to discuss about the construction of one of the alternative energy resources in specific location, Ankara." (FI_G8_ME, VSRI)

To some up, PSTs pointed out the role of the selected SSI topic in their effectiveness of the teaching performance. Based on their theoretical knowledge and their experiences in their teaching performance, they got an idea about the role of case based issues on their effectiveness in SSI teaching. Although they were able to determine students' prior knowledge or possible misconceptions related to the issue and designed a good lesson plan by considering these, they may not be effective in teaching, if the selected topic was not appropriate. Therefore, they admired the importance of topic selection in SSI teaching. They understood that if they selected an SSI topic relevant and meaningful to learn for students, they could ensure active participation of students and manage argumentative discourse easily. Based on their evaluations of their group performance, it can be inferred that in order to teach an SSI effectively, the selected topic should be as much specific as students can handle. Moreover, the topic should be related directly to students' daily life experiences and it should be attractive enough to engage students in such challenging activities. The complexity of the scientific background of the SSI topic should also be appropriate for students' understanding. Lastly, the SSI topic should provide students an opportunity to develop care and empathy so that they can internalize the topic and be willing to participate in classroom discourse.

4.1.2. SSI topic knowledge

In addition to the characteristics of the selected SSI topic, PSTs' knowledge about the selected SSI topic was also influential in their effectiveness in SSI teaching. Effective groups in SSI teaching attributed their success to their being well-prepared in terms of the arguments about the topic. They stated that all group members studied the arguments and they all were knowledgeable enough to guide students effectively.

> "FI_G8_ME: We were guessing the arguments of the opposite group. We said to the groups that the other group might say this. Therefore, we effectively guided them in thinking from two opposite point of views." (FI_VSRI_G8)

> "SI_G5_BKS: I was quite prepared to the topic. I took notes about pro and con arguments. I guessed in advance, what I could encounter. I had evidences for each claims. I did not have difficulty in guiding students." (SI_VSRI_G5)

> "SI_G6_OU: I think we were well-prepared because every group member was very knowledgeable about the details of the topic. (SI_VSRI_G6)

The sixth group of the second implementation performed a panel discussion at the end of the lesson for collective decision making. They effectively managed the panel. The manager of the panel stated that he was well-prepared for the arguments.

> SI_G6_DC: I wrote everything to my notes by formulizing. There were not full sentences but some clues about what can I do in which case.
> SI_G6_DT: There were possibility kinds of notes.
> SI_G6_DC: I wrote, for example, what I can do if there were two agree and one disagree decision. (SI_VSRI_G6)

On the other hand, the first group of the second implementation mentioned about their difficulty in dealing with students ideas when the students proposed claims that they did not expect.

> "SI_G1_CU: This was something that I really do not know. We did not talk about this argument. We did not consider that the students who are coming from HES regions could address the issue from economical perspective.
> SI_G1_AO: Yes, they asked this but I did not know. I immediately started to think about the year of the video about Hasankeyf. I remembered that it was an old video. I guessed that the construction of that HES should be completed. I said like this but I had doubts and I was not very comfortable about my answer." (SI_VSRI_G1)

Moreover, this group did such a job share that only one of the group members were responsible from managing the whole class discussion and the PST who managed the discussion was not very effective. That PST stated that she was not knowledgeable about the claims and evidences.

> "SI_G1_EC: At this point, I was saying to my friend that I am not much knowledgeable about the evidences, please support me during discussion." (SI_VSRI_G1)

The PSTs who felt themselves insufficient in their knowledge about the SSI topic stated their inefficiency in evaluating stuents' evidences and encouraging them to find scientifically acceptable evidences.

> "We were not effective in evaluating students' evidences for their arguments because of the lack of time and not being well-prepared. We were not effective in encouraging the students to find scientifically acceptable supporting evidences for their claims." (FI_G5_SA, RP_2)

Therefore, based on PSTs evaluation of their own performance, the effectiveness of their implementation of argumentation was directly related to their knowledge about the issue. Although they have theoretical knowledge about the argumentation as retrieved from the lesson plans, they were not able to manage the argumentation effectively due to lack of knowledge. Therefore, in order to teach an SSI topic effectively, the teacher should be quite knowledgeable about the details of the issue. The teachers should be prepared about the possible arguments and evidences related to them.

However, most of the groups were not able to express the arguments related to their topic in their lesson plans. Only three of the groups from the second implementation mentioned clearly from the arguments that can be considered as the indicator of having a grasp of the topic. One example to summary of the arguments that was given in group lesson plans was provided below.

> "Improves the quality of foods. (pro 1) Studies which are doing to improve the quality of food harm to human body. (Counter 1) Increases the benefits of nutrients for health (pro 2) Cause allergic reactions. (Counter 2) Reduce the use of insecticide when raising food. (pro 3) Damages distribution of the species and the balance in the ecosystem. (Counter 3) Helps for food allowance for less developed countries. (pro 4) Lack of tagging (Counter 4) Producing more products. (pro 5) Difficulties for selling because of more products in marketplace (counter 5) Cheaper products for consumers (pro 6) Low quality products (counter 6) (SI_G3, GLP)

Their deficiency in the SSI topic knowledge affected the subsequent processes in planning and teaching. As it was mentioned, groups were asked to write objectives for different learning areas. All of the groups were able to write related objectives from knowledge learning area of the curriculum. They directly extracted the objectives from the curriculum; generally, they did not restate or write new objectives. The following quotation is an example to knowledge objectives of the second groups of the first implementation. Although the second objective is about affective domain, they stated it as knowledge objective.

> "8.5.4.1. Give examples about the working areas of biotechnology.
> 8.5.4.2. Participate actively in class discussion.

8.5.4.3. Summarize the knowledge about the applications of genetic engineering in present time." (FI_G2, GLP)

Most of the groups (n_{FI}=4 and n_{FI}=5) wrote knowledge objectives at most in 'understanding' level according to Bloom's taxonomy of educational objectives as in the following quotation. They expected their students to comprehend the issue and the scientific knowledge related to the issue.

"Define alternative energy sources
Exemplify alternative energy sources." (FI_G8, GLP)

One of the groups even wrote objectives only in the first level, which is defined as 'remembering' in Bloom's taxonomy.

"Students will be able to: - Realize the basic idea behind gene therapy; viral vectors. - Recognize gene therapy is to restore normal function in cells affected by genetic disorders. - List relevant facts about the issue. - Be aware about the risks and potential outcomes involved in actual gene therapy." (FI_G6, GLP)

Four groups (n_{FI}=2; n_{FI}=2) wrote objectives in 'analyzing' level. These groups expected students to do search, analyze their findings, and make decision about some issues related to the selected SSI. Moreover, they expected their students to understand the different concepts by comparing the characteristics of the concepts.

"At the end of the lesson students will be able to, -Estimate the results of developments in genetic engineering. -List the biotechnological working areas. -Explain the human cloning. -Search and present the controversies of the human cloning with different perspectives (scientist, ethicist and legislator.)" (FI_G5, GLP)

"Explain the cloning techniques. Explain the differences between natural twins and clones." (SI_G8, GLP)

Two groups from the second implementation wrote objectives in 'evaluating' level.

"-To explain current application about genetic engineering -To predict consequences of genetic engineering in humanity -To evaluate the positive results of genetic engineering -To explain the importance of biotechnological research -To illustrate about gene therapy" (SI_G4, GLP)

Only one of the groups from the first implementation wrote objectives at the highest level, which is creating. They expected their students to produce a material about the issue to inform the society.

"7. Produce a public booklet to share your findings." (FI_G7, GLP)

Those groups who wrote higher levels of knowledge objectives were quite knowledgeable about their SSI topic. All of the group members could easily respond to students' unexpected arguments and guided their discussions effectively.

Moreover, the groups, who were not knowledgeable about their SSI topic, were not much effective in doing assessment through technological devices compatible with the curriculum's evaluation and assessment perspective. Since they did not know the arguments related to their topic, they could decide neither what to assess, nor how to assess. On the other hand, the group who were well-informed about their SSI topic were also effective in their assessment practices.

Generally, the knowledge of PSTs in the second implementation was better than the PSTs in the first implementation. The reason may be related to the changes about the design of the course decided after the first implementation. Since we observed that PSTs had difficulty in guiding argumentative discourse due to lack of knowledge, they were urged to increase their knowledge about the selected SSI topic. For this reason, they were devoted another half hour to present their SSI topic to the classroom before their teaching performance. Therefore, in order to present the arguments from different perspectives related to their SSI topic, they had to increase their knowledge about their SSI topic.

This change in the design of the course resulted in better performance in presenting the arguments related to their SSI topic and assessing students' understanding about the arguments. About knowledge of assessment with technology in effective SSI teaching, the groups in the second implementation were evidently more effective than the groups in the first implementation. They were more effective both in diagnostic and formative assessment.

The groups in the second implementation used different techniques to reveal students' prior knowledge in addition to questioning. They did not only rely on questioning as in the first implementation. Two of the groups from the second implementation used online quizzes. The second and fourth group from the second implementation used Socrative before they started to the presentation of the issue. With the help of these quizzes, students in their groups became engaged in the lesson from the beginning. The quizzes were helpful in catching students' attention.

The seventh group in the second implementation attached the quiz questions to their lesson plans and wrote the purpose for asking each question included in the quiz. They stated the related objectives for each question as it was given below partially.

> "Question 1: How is the pharmacy profession related to biotechnology? Explain briefly. (OBJ. 2)
> Question 2: Is scientific knowledge changeable on the basis of experiments? State your opinion clearly. While answering, consider your debate with your group friends. (OBJ. 3)
> Question3: Form an estimate of last medicine you used in terms of animal testing experiments according to Table.1 below. (OBJ. 1)" (SI_G7, GLP)

The sixth group of the second implementation used online quiz in different format. Since their topic was new for students and they learned the concepts related to the issue in the first week, the group used summative assessment at the beginning of the next week. They tried to figure out what they learned in the first week and how much they were able to remember about the arguments related to the topic. For this purpose, they prepared and applied a Kahoot quiz. Their implementation of the quiz was very successful. They prepared a short quiz including one or two questions related to the each aspect. After students answered each question, the teacher reviewed the results and reminded the arguments. The members of above mentioned two groups were quite knowledgeable about the arguments of their SSI topic from every aspect. Therefore, their teaching and assessment practices were more effective as compared to the other groups. Since they knew what to assess, they did not have difficulty in finding ways to assess.

The groups in the second implementation were also more effective in formative evaluation, although all of them used similar techniques to assess students for this purpose. All of the groups observed students during group discussion, monitored their progress from the teacher computer by looking at the collaborative writing files. Some of the groups used rubric to do this in a more systematic way. While doing these, generally the groups in the second implementation were more effective, because all of the group members were responsible for guiding students in these processes. Since in the second implementation, generally the awareness of PSTs about the arguments related to their SSI topic were higher as compared to the PSTs in the first implementation, all of the group members were knowledgeable about the arguments. Therefore, they effectively assessed students' quality of their arguments in group discussions. The teachers facilitated students to find more evidences when needed. Thus, all of the group members were active in evaluating students' argumentation skills and guiding them accordingly. PSTs' assessment of students' argumentation skills were elaborated in 4.2.2.5.

4.2. Classroom Discourse Issues

In the comprehension stage of the course, the pedagogy of SSI teaching was discussed. Therefore, PSTs were expected to read articles related to the pedagogy of SSI. The research-based framework for SSI education defined by Zeidler et al. (2004) was discussed with an emphasis on the four areas of pedagogical importance central to the teaching of SSI, which are case-based issues, NOS issues and classroom discourse issues. Therefore, the pedagogical power of reasoned argumentation and the importance of developing students' views about science through argumentation were emphasized. Therefore, in this section, the groups' pedagogical decisions in organizing argumentative discourse, both written and spoken, were explained.

Except two of the groups from the first implementation, all of the groups in both implementation tried to engage students in argumentative discourse. As it was mentioned in the case-based issues section, these two groups could not determine a socio-scientific issue to cover in their lesson plan and teaching performance. Therefore, they were not able to consider discourse issues that are central to SSI teaching. The other 14 groups tried to engage students in argumentation. In their lesson plans, these groups tried to define argumentation and to explain teacher and student role in argumentation. Most of the groups (n=11) provided a general description of argumentation as in the following quotation.

> "Argumentation is kind of practice through which scientific knowledge claims are justified and evaluated based on theoretical evidence and some groups try to convince others having different thought via talk about the validity of a particular evidences." (FI_G1, GLP)

However, three groups from the second implementation provided more detailed description of argumentation by considering the elements of argumentation. They had a clear theoretical knowledge about argumentation and used this information in planning their activities. These three groups' elaborated definitions of argumentation were given below.

> "In argumentation teaching strategy, it is important for students to consider several steps which are;
> · Claim: In this step students form their own claims about the particular content.
> · Justification: In this step students support their claims with evidences.
> · Counter-position: In this step students consider what might be the critics for their claims.
> · Rebuttal: In this step students finds evidences in order to rebuttal the opposing ideas to their claims." (SI_G6, GLP)

> "Argumentation method has four stages: 1st stage; students have a claim but not able to justify that claim or offer other argumentation structures, 2nd stage; students have a justification of their claims, 3rd stage; students response included justified claims as well as at least one counter position, 4th stage; student presented justified claims, at least one counter-position, and a rebuttal to the counter position." (SI_G2, GLP)

> "Toulmin's argument components are used in order to construct arguments in argumentation. These components are qualifier, data, claim, rebuttal, backing, warrant and data. What are the explanations of these components:
> - Qualifier: Express the grade of certainty or uncertainty (e.g. 'probably', 'for sure', 'it depends').
> - Claim: Assertions about what exists or values that people hold (has to be supported or disproved).
> - Rebuttal: the statements that acknowledge the restrictions or exceptions to a claim (specify the conditions when the claim will not be true).
> - Backing: a statement further supports the relations between data and

> claim theory (strengthen the acceptability of the warrants).
> - Warrant: Statements that explain the relationship of the data to the claim (justify why data are relevant to the claim)
> - Data: Observations, facts or experiments that are used as evidence to support the claim" (SI_G1, GLP)

About teacher role in argumentation, all of them appreciated the need for being facilitator but mostly they did not explain how to facilitate argumentation as in the following quotation.

> "In argumentation technique, the teacher is more of a facilitator of learning, or a coach, than a transmitter of knowledge." (FI_G8, GLP)

Rather than stating the role of teacher specifically in argumentation, groups mentioned the teacher role in organizing and managing classroom efficiently. They mentioned the need for monitoring students' progress without giving specific criteria to evaluate the students' progress in argumentation.

On the other hand, three of the groups from the second implementation elaborated the role of teacher in argumentation by referring to some theoretical knowledge retrieved from articles or including some specific questions for teachers to consider during argumentation. They were clearly aware of their role in facilitating argumentation and evaluating students' arguments.

> "Argumentation is student centered and so teacher behave like a facilitator, observer. According to Osborne, Erduran, Simon and Monk, teacher acts like initiator of argumentative discussion by using arguing prompts like "Why do you think that"," What is your evidence"." (SI_G1, GLP)

> "Teacher should consider these questions; How to introduce argument? How to manage small group discussion? How to teach argument? Which resources can be used to support argumentation? How to evaluate arguments?". (SI_G3, GLP)

> "Teacher role in argumentation is to encourage discussion, define the argument, encourage students to share ideas, check evidence base of students, provide evidence for students, encourage students to make presentations, encourage evaluation, encourage students to anticipate counter arguments, encourage reflection and ask students if they changed their minds. Shortly, teacher is a facilitator during an argumentation". (SI_G6, GLP)

Regarding the students' role in argumentation, two of the groups from the first implementation and three of the groups from the second implementation did not refer to any role of students. Others mentioned the role of student by explaining what they were expected to do step by step as in the following quotations from two groups of second implementation. While explaining student role in argumentation, these two groups also referred to technologies that students were expected to use.

> "Firstly, each small group will decide their claim by reading articles which are in beyaz pano or doing research to find new opinion for 10 min. After deciding their claim, they will share it with opposed small group (agree group X disagree group) with using beyaz pano. Thanks to beyaz pano students can see opposite group's claim and start to make counter for these claims for 10 min. Lastly, finishing the produce claims and counters, large group (such as farmers) come together in each and make discussion to decide their group's decision about GMF for 10 min." (SI_G3, GLP)

> "Students will produce claims, support their claims with evidences, consider the counter arguments and rebuttal the counter arguments during group discussions and the teacher will observe students during discussion. After the discussion ends, students will share their ideas through the google documents." (SI_G6, GLP)

On the other hand, although fifth group of the first implementation did not refer to elements of argumentation defined in Toulmin's argument model as in the above quotations, they mentioned the role of students by emphasizing their role in communication during the activities.

> "In argumentation, students learn from each other and respect their friends' ideas. During argumentation, students will conduct discussion to solve a socio-scientific issue. Each student will bring their own worldview and they will come up with a consensus on the solution." (FI_G5, GLP)

As a conclusion engaging students in argumentation was the main goal of all groups (n=14) except two groups from the second implementation. Among these 14 groups, 2 of them (fifth and eighth group from the second implementation) did not mention anything in their group lesson plans to explain the basis of argumentation, and student and teacher role in argumentation. Therefore, it can be inferred that although engaging students in argumentative discourse was their main goal, they did not provide theoretical background knowledge about argumentation. Contrary to these groups, first and sixth group of the second implementation provided a detailed information about the definition of argumentation, teacher and student role in argumentation by referring to the related theoretical knowledge. Therefore, based on their group lesson plans it might be inferred that PSTs in these groups were quite knowledgeable about argumentation.

PSTs were also asked to give details about the main instructional strategies they planned to implement in their individual lesson plans. Similar to their group lesson plans, all of the PSTs tried to engage students in argumentation. Although all of them used argumentation as it can be clearly retrieved from the lesson flow of the plans, 55 PSTs (28 from first implementation and 27 from second implementation) provided description about argumentation. A representative definition of argumentation provided by PSTs in ILPs was given as follows:

> "I will use "argumentation strategy". Argumentation refers to the process of constructing an argument and its justification whilst the term argument refers to its substantive content (the product, statement or piece of reasoned discourse). Different definitions of argumentation are also made. A discursive practice through which scientific knowledge claims are justified or evaluated based on empirical or theoretical evidence (Jiménez-Aleixandre & Erduran, 2007). A social activity in which an individual tries to convince others either through talking or writing about the validity of a particular assertion (van Eemeren & Grootendorst, 2004). Teachers could engage students in the construction of arguments through the process of argumentation. According to Turkish Science Curriculum, teachers are expected to encourage students' argumentation and evaluation of alternative ideas and also to mediate debates and activities in a way so as to allow for the possibility of students' own constructions of scientifically accepted views and mindsets... (2013 Science Curriculum, p. 3)". (FI_G6_BE, ILP)

As it can be seen from the quotation, PSTs developed an understanding about the definition of argumentation. They were generally aware of the different definitions of argumentation. Moreover, they became aware of the place of argumentation in the Turkish Science Curriculum. In the current science curriculum implemented in Turkish schools, argumentation is explicitly suggested for organizing learning environment in which students are active and teacher is facilitator. Moreover, the role of teacher in developing students' argumentation skills was clearly explained. Since

PSTs examined all of the parts of the curriculum in completing the requirements of the course, they gained awareness about the importance of argumentation in the curriculum. Therefore, although they provided bookish definitions of argumentation in group lesson plans, they started to refer also to the curriculum.

Moreover, PSTs were also aware of the elements of argumentation that indicates the quality of argumentation. Therefore, this knowledge about the quality of argumentation reflected on their considerations in assessment process. They became quite knowledgeable about how to decide the quality of argumentation performed in the classroom.

> "In argumentation, students should satisfy the stages:
> 1. Claims that refer to status of students to a socio-scientific issue and include conjectures, conclusions, explanations, models, or an answer to a research question.
> 2. Justifications refer to supporting the claims with some explanations and the claims should rely on evidence to support.
> 3. Counter-positions are the claims that can be as an opposition to the original claim and it is important to satisfy this step because in this way students are able to see the issue in multiple perspectives.
> 4. Rebuttals are important for supporting the original claim against the counter-position." (SI_G6_OU, ILP)

Teacher role for engaging students in these steps was also emphasized in the Turkish science curriculum:

> Teachers help their students in engaging such dialogs that students can express their ideas freely; justify their ideas with different warrants and construct counter-arguments to rebut their friends' arguments. Teachers take the role of facilitator and guidance in written or oral discussions that include counter-arguments, students' claims constructed based on valid evidences and presented with rational justification. (MoNE, 2013, p.3)

PSTs also emphasized the importance of argumentation in SSI teaching. In the comprehension stage of the course, the pedagogy of SSI teaching was discussed with related literature. Moreover, they observed effective practices of the groups applying argumentation in their teaching practices. Therefore, their ideas about the congruency of argumentation with SSI teaching were strengthened. Then, they referred to this congruency while defining argumentation in their lesson plans.

> "In order to address this issue it is important that methods such as argumentation are used which involve students in discussion and thinking processes which Abrahams and Millar (2008) refer to as having 'minds on' the science." (SI_G2_ET, ILP)

> "Argumentation is the most suitable teaching strategy, because students need to construct scientific explanations about the socio-scientific issues where they justify their claims using appropriate evidence and scientific reasoning to try to persuade either themselves or others about the validity of those claims. Therefore, argumentation is an important component of inquiry process and it is necessary to portray scientific knowledge as socially constructed. Also, in order to assess the lesson in terms of quality, argumentation is as an indirect measure." (SI_G5_HY, ILP)

Acknowledging the importance of argumentation in the current science curriculum and appropriateness of it for SSI teaching, PSTs preferred to implement argumentation in their lesson plans and designed their instructional activities to facilitate argumentation. By using argumentation, PSTs aimed to develop students' thinking skills, communication skills and decision-making skills and to promote informed citizenship as stated in their lesson plans.

> "Students' critical thinking will be improved because they will justify their claims based on their evidences. They will work with their group friends and this will improve students' collaboration skills." (FI_G1_AG, ILP)

> "I chose argumentation, because for this SSI students should discuss and make class decision. Therefore this requires constructing their own knowledge, developing good communication skills and increasing decision making skills." (FI_G8_AD, ILP)

By trying to help students reach the fourth stage in argumentation, PSTs aimed to contribute students' scientific literacy.

> "Nuclear energy is a controversial issue nowadays. This socio-scientific issue can be implemented in the classrooms. I can contribute to the student's scientific literacy and their critical thinking ability. Accordingly, I chose argumentation method for this topic." (FI_G5_AK, ILP)

As they stated below, by engaging students in argumentation, PSTs also aimed to imitate scientific discourse carried in community.

> “I will use argumentation/in class discussion. These are needed because of that student will do research among the directions and they will have their own conclusions. These conclusions should be presented to the other class members in order to strengthen or to recognize the weak sides of their opinions. Thus, all class members work like a scientist.” (FI_G2_BU, ILP)

Moreover, some of the PSTs aimed to elicit and overcome students’ misconception during the argumentative discussion.

> “Because of our subject is a socio-scientific lesson about the organ donation and transplantation and argumentative strategy is a best way to achieve success in class. Misconceptions and prior knowledge may easily understood by teacher. Thanks to knowing prior knowledge of students related to organ donation, we can build new subject starting from prior knowledge and thanks to knowing misconceptions of students related to organ donation, we can eliminate them during lesson, during argumentation.” (FI_G4_EA, ILP)

> “Argumentation requires making claim and supporting these claims. Therefore, students get a chance to prove or refute their ideas while they are learning science concepts. While students are discussing science concepts, they get knowledge about others. This helps to eliminate students’ misconceptions.” (SI_G3_FK, ILP)

As it can be seen from the quotations, PSTs stated clear purpose for implementing argumentation in their SSI teaching. They acknowledged the benefits of argumentation in SSI teaching and aimed to take advantage of it in line with their purposes. Among the ones who provided description for argumentation, almost all of the PSTs (n = 43) mentioned the advantages and most of them (n = 37) stated the disadvantages of argumentation.

PSTs admired the potential of argumentation in developing students’ higher order thinking skills like critical thinking, decision-making and problem solving skills. Moreover, PSTs mentioned the importance of argumentation in promoting students’ scientific literacy and contributing their understanding of nature of science.

> “Developing scientific literacy because students will read articles and news about the issue and they evaluate the findings in their mind.
> * Assisting in the development of NOS understanding
> * Developing decision making about SSI
> * Increasing critical thinking & reasoning
> * Comprehending epistemological basis of scientific practice

* Developing communication between students" (FI_G8_CAY, ILP)

> "This will give them chance to develop their thinking abilities since they will think from other perspectives, they will think on positive aspects and negative aspects. By doing these, they will also search for evidences from literature. For this reason, they will be more scientifically literate person." (SI_G8_AS, ILP)

PSTs also praised argumentation for its capability of developing students' 21st century skills like collaborating and communicating.

> "With these strategies, student will have an opportunity to increase their cognitive, social, 21st century and communicative skills. They will develop their moral and ethical judgment and they will impress their feelings. With this strategy, I will take their attention to the topic easily." (SI_G5_NFO, ILP)

Moreover, PSTs mentioned the advantage of argumentation in terms of facilitating students' decision making so that they can participate in democratic processes in the society as scientifically literate individuals.

> "An outcome of science education is that young people have the understandings and skills to participate in public debate and make informed decisions about science issues that influence their lives. Toulmin's argumentation skills are emerging as an effective strategy to enhance the quality of evidence based decision making in science classrooms." (SI_G5_BÇ, ILP)

> "This teaching strategy enables students to confront, negotiate and make decisions in everyday life situations. It improves students' verbal expression abilities as well as moral and ethical considerations because students need to think about both scientific and social aspects of the issue and then make decision. It help students to feel capable of make decision and see themselves as a part of the society." (SI_G6_OU, ILP)

PSTs were also aware of the disadvantages of argumentation. To compensate these disadvantages they took some precautions. Most of them think that students may not participate actively if they do not have enough prior knowledge.

> "If students don't have enough previous knowledge so that they can grasp gene cloning, they will not participate the discussion actively." (FI_G1_AK, ILP)

To overcome this problem, most of the PSTs planned activities to help students learn the topic and the arguments about the SSI topic well before starting the argumentation. Moreover, PSTs had some concerns about student participation that the classroom environment may not facilitate the participation of shy students. The possible chaotic classroom environment may be an obstacle to ensure active participation.

> "Students can be shy; they do not want to share their ideas" (FI_G8_CAY, ILP)

> "Many students lack the ability to communicate complicated opinions to an audience effectively. Students can acquire better argumentation skills through conceptual work, theoretical readings, and practical experience. Apart from these, argumentation method should be implemented in a democratic classroom environment. If the teacher does not consider this situation, some of students can dominate other students' ideas. By this way, the main goal of the lesson will not be reached. Classroom management and time issue also can be problem." (FI_G6_DC, ILP)

PSTs were also aware of the difficulty of managing argumentation.

> "-Some students will not say their ideas about issue due to characteristic of student, - Arriving a conclusion can be difficult, -Time consuming and this method takes a lot of time, - Understanding of students' misconception can be difficult, - Observing whole class can be difficult since teacher will not focus all students in the same time (SI_G2_ET, ILP)

To overcome these obstacles they planned to take advantage of technology. By allowing written argumentation on online environments, PSTs planned to facilitate passive students' participation. Moreover, they planned to use technology to pursue students' ideas easily so that manage the argumentation effectively.

> "It is really important for argumentation technique to observe students' progress and check whether pupils are constructing solid claims, evidences, counter-arguments and rebuttals. For this purpose, teacher uses google documents in order to check students' progress while discussion and also google document page is helpful for students to have an overall look to the discussion." (SI_G6_MCO, ILP)

Therefore, PSTs decided the appropriateness of argumentation in SSI teaching by analyzing the advantages and disadvantages of it.

About teacher role, as in the group lesson plans, most of the PSTs (n=34) who selected argumentation appreciated the need for being a facilitator as teacher. Although they could not clearly articulate how they can facilitate argumentation in group lesson plans, PSTs expressed the ways they can facilitate argumentation in individual lesson plans. While discussing their role in argumentation, most of the time, PSTs referred to the literature.

They stated that in argumentation, discussion should be student-led; however, teachers have responsibility to facilitate students' discussion with different activities.

> "In an argumentation activity discussion should be 'student-led'. The teacher should have the role of facilitator by scaffolding tasks, setting up collaborative small group discussions, and asking probing questions to encourage students to justify claims and challenge their own reasoning. Teacher can reach this aim by:
> - Providing hints, - Calling for reasoning, - Driving towards the focal point, - Helping to make connections, - Encouraging wider response, - Pointing out flaws in the argument, - Asking for justification, - Asking for explanations, guesses, inference (Kawalkar & Vijapurkar, 2011)" (FI_G4_SNA, ILP)

They mostly stated that teacher has the responsibility to provide arguments to students to encourage students for effective discussion. Teacher should provide necessary knowledge and scaffolding. Moreover, teacher should be able to monitor students during argumentation and follow students' arguments.

> "Define the concept of fish farming. Provide con and pro argument to students. Becoming guide them. Monitor them. Listen them and help them to reach an agreement (first group agreement and then class agreement). Similarly, Erduran, Ardac & Yakmaci-Guzel (2006) state that, the teachers structured the task, used group discussions, questioned for evidence and justifications, modelled argument, used presentations and peer review, established the norms of argumentation, and provided feedback during group discussions." (SI_G1_EC, ILP)

Moreover, PSTs stated some guiding question to determine their role in argumentation. One of the PSTs answered these guiding questions to clearly define her role and evaluate her implementation of the strategy.

> "Teacher determines strategy based on these questions;
> - How introduce argument?: With prezi slayt show.

> - How manage small group discussion?: I will be around them and be like guidance.
> - How teach argument?: Using argumentation technique. Student will come class well prepared to topic after argumentation they will learn each details of stem cell.
> - Which resources can be used support argumentation by students?: They can use my resources which I will upload to beyaz pano.
> - How evaluate arguments?: I will assess them with classdojo program according to results I will understand my method is okay or not." (SI_G3_SK, ILP)

According to PSTs, in order to guide students' argumentation effectively by encouraging them to find evidences for their claims and refute other claims, teacher should have necessary knowledge about the topic.

> "Teacher is not active during the discussion however, if the students need some directions in formulating well-supported claims and some technical supports teacher should interfere and help students to have a smooth discussion environment. In this lesson, it is important to practice the duties of teacher so that the lesson can continue as expected." (SI_G6_OU, ILP)

> "Teacher should be good at the topic because students can ask so many questions because they are very curious. Teacher also should be good at the technology because this lesson require the integration of technology. Also, teacher will not give the conclusion directly, help to students while students are reaching the conclusion. Teacher will observe the students while working as a group, because if students were not observed, they can talk out of the topic. Teacher should manage the time very efficiently, because argumentation lasts long. Some students can be intrapersonal, so teacher should encourage them. Teacher should be a sure everyone is talking about the topic." (SI_G4_FO, ILP)

To sum up, PSTs listed many responsibilities of teacher to facilitate the argumentative discourse effectively. Since they mostly referred to the literature, it can be inferred that they gained theoretical knowledge about implementation of argumentation strategy.

Similar to teacher responsibilities, PSTs mentioned responsibilities of students in argumentation. Since they thought that argumentation is a student-centered strategy, they mentioned the active role of students. They mostly emphasized active knowledge construction of students, which was the indication of PSTs' understanding of the role of social constructivism in SSI teaching and learning.

> “Argumentation is a student-centered approach and involves students building upon their own ideas. Students are at the center of argumentation. Through collaborative group work and small group discussion, students are encouraged to reason for themselves the validity of any given claim. During discussion, there will be indicators, which should suggest whether the students are engaging with argumentation process. (Osbourne, Erduran, and Simon, 2004)” (FI_G6_BE, ILP)

All of the PSTs mentioned student roles according to the steps in argumentation they mentioned in the definition of the instructional strategy. Briefly, they mentioned students’ role in developing claims, finding evidences to justify their claims, being aware of the counter-arguments and rebutting these counter-arguments with scientific evidences.

> “Students has a main role, that is, investigating about the nuclear power plant, trying to find pro and con arguments, trying to examine this issue from different points of views, finding counter arguments for their own claims, listening their friends, refute others’ ideas, developing moral judgments, observing event mentioned in the videos and making inferences, etc.” (SI_G5_NFO, ILP)

Most of the PSTs assigned roles to the students like being scientist, ecologist, economist, commoner etc. Therefore, they expected students to behave and think according to their roles while constructing their claims, searching for justification to their claims and rebutting the counter-arguments.

> “One group is health personal, other is public, third group is farmer and genetic engineers. Each group make research and they will make a decision whether organisms' genetic should be changed or not. They will get their evidence with their researches. Then, they will share their ideas in the class. They will present their claims and evidences scientifically. Students can support or make counter argument for other groups’ claims.” (FI_G5_SA, ILP)

> “- Share their ideas with their partner, - Listen carefully to their partner’s ideas, - Be a good listener, attending and responding to other’s contributions, - Complete the role task, - Share findings and participate, - Support and encourage other group members, - Questioning each other’s’ ideas with references to the data, - Building on other students’ arguments thorough clarifying or modifying, - Reasoning and justifying ideas, - Evaluating others’ ideas for their strengths and weaknesses (Osbourne, Erduran, & Simon, 2004)” (FI_G4_SNA, ILP)

PSTs also stated that students are responsible from their own learning. Moreover, they have potential to contribute each other's' learning. These ideas about the role of students were also the indicator of their understanding of social constructivism in SSI teaching.

> "Students will learn information by themselves, from their friends and from technological sources like the Internet by looking for scientifically correct evidences. Then they will use all of those to have idea about socio-scientific issue and to solve this issue according to their researches and argumentations." (SI_G8_AS, ILP)

> "Students discuss and defend their ideas or solutions with team-mates; they learn to think problems through, to support their own opinions, and to critically consider the opinions of others before coming to a conclusion. And they learn that, in the end, the responsibility for learning still rests with them. Teacher used it for understanding global warming. Because when they are searching, they can share ideas. They can help each other for better understanding. They will have to find some solutions about global warming. So, working with discussion in groups is a good way." (FI_G3_CY, ILP)

Moreover, as in group lesson plans, PSTs referred to students' technology use while mentioning their role in argumentation.

> "They will develop their technological skill while using blog, quia etc" (SI_G4_FO, ILP)

> "Fourthly, they should write their thoughts to express their evidences/claims on the Google doc. And they should make collaboration by choosing group speaker and writer on the Google doc., they should be aware of the time by doing these all." (SI_G5_HY, ILP)

When we look at PSTs' explanation of argumentation, it can be said that their understanding of argumentation developed from their group lesson plans to the individual lesson plans which they prepared at the end of the course. There are not differences in two implementations in terms of PSTs' development of argumentation knowledge. At the end of both implementations, PSTs were able to state clear definition of argumentation, select argumentation for their own purpose by considering the advantages and disadvantages of argumentation, explicate their own and their students' role in implementation of argumentations. Moreover, they developed an understanding about the role of argumentation for designing a social constructivist learning environment.

4.2.1. Facilitation of argumentation about SSI through different instructional strategies

In order to engage their students in argumentative discourse, PSTs planned to use different instructional methods in their group and individual lesson plans (Table 14). When the instructional strategies used by groups and the individual PSTs were examined, it was found that cooperative learning was the most frequently used instructional strategy. Questioning, discussion and direct instruction are other frequently selected instructional strategies.

Table 14
Instructional Methods/Strategies Planned to be Used to Engage Students in Argumentation

Instructional methods/strategies	**Number of groups planned to use**		**Number of PSTs planned to use**	
	FI	SI	FI	SI
Cooperative learning	4	5	23	24
Questioning	4	3	15	9
Discussion	2	1	10	6
Direct instruction	1	2	3	9
5E	1	-	4	-
Online scaffolding	-	-	4	1
Role playing game	-	-	1	1

4.2.1.1. Cooperative learning

In Turkish Science Curriculum it is clearly stated that planning and enacting lessons is based on learning environments (problem and project based learning, argumentation, cooperative learning) in which students are active and teacher is the guide and facilitator (MoNE, 2013). Therefore, cooperative learning was equally emphasized in curriculum similar to argumentation. In line with the suggestions of the curriculum, nine of the groups planned to use cooperative learning in their teaching and gave some information about the details of it. Two of the groups (n_{FI}=1, n_{SI}=1) preferred more specific type of cooperative learning strategy, jigsaw. Similarly, cooperative learning strategy was the most frequently selected instructional strategy in individual lesson plans (n_{FI}=23, n_{SI}=24). Among these PSTs, three of them decided to use a more specific collaborative learning strategy, the reverse jigsaw approach.

Among the groups using cooperative learning, four of them (n_{FI}=2, n_{SI}=2) gave a detailed description of what cooperative learning is and what the elements of it are as in the following quotation as in the following quotation. On the other hand, 4 groups (n_{FI}=1, n_{SI}=2) only stated cooperative learning as an instructional strategy including cooperation of students in group works, and two of them (n_{FI}=1, n_{SI}=1) even did not stated any definition.

> "According to the Johnson & Johnson model, there are 5 key elements in cooperative learning: - Positive Interdependence: Students perceive that they "sink or swim together". - Individual Accountability: Students learn with group member, but they preform knowledge individually. - Face-to-Face (Promotive) Interaction: Provide promotive interaction - Interpersonal and Small Group Social Skills: Students learn academic subject and interpersonal and small group skills - Group Processing: Involve task and team work." (SI_G1, GLP)

On the other hand, PSTs provided more theoretical information about cooperative learning. Among the PSTs who selected cooperative learning, 31 of them mentioned clear definition of it theoretically.

> "Teaching strategy is cooperative learning. Cooperative Learning involves structuring classes around small groups that work together in such a way that each group member's success is dependent on the group's success. There are different kinds of groups for different situations, but they all balance some key elements that distinguish cooperative learning from competitive or individualistic learning" (FI_G3_CY, ILP)

> "The main points of cooperative learning are: 1) Positive interdependence: members of a group who share common goals perceive that working together is individually and collectively beneficial, and success depends on the participation of all the members. 2). Individual accountability: each student in a small group has individual responsibilities. 3) Face to face interaction: with the group members and the teacher as well. 4) Social skills and effective group processing." (SI_G6_DT, ILP)

Moreover, PSTs revealed more clear purpose for preferring argumentation as the instructional strategy to facilitate argumentation. They clearly explained the advantages and disadvantages of cooperative learning in their individual lesson plans. They preferred to use cooperative learning to facilitate implementation of argumentation.

> "I applied cooperative learning teaching strategy because before argumentation, students should research, collect data and information and learn topic in detail from different aspects so cooperative learning is needed for this stage." (SI_G3_AFE, ILP)

Moreover, they decided to use cooperative learning due to its appropriateness in teaching SSI based on the literature.

> "Erduran (2007) presents that socio-scientific issues should be learned with working cooperatively because these kinds of issues are not thought in a one dimension. There is no one certain truth or mistake. It can be handled multi perspective." (FI_G3_MSY, ILP)

Most of the PSTs (n=39) mentioned variety of advantages of cooperative learning strategy. Among those, the most salient one was the potential to develop students' communication and collaboration skills, which are defined as 21st century skills.

> "To promote communication and collaboration skills in students, cooperative learning is the best. Moreover, in cooperative learning students take responsibility." (FI_G1_MK, ILP)

> "Students are more likely to learn from their peers and most of the similar questions will be asked and answered in the group discussion. Positive interdependency can be developed as individuals feel that they cannot succeed unless everyone in their group collaborates and they will accept the fact that there are opposite ideas to them. Interpersonal and collaboration skills can be learned in this activity since they work in collaboration." (SI_G7_IT, ILP)

PSTs also admired the potential of cooperative learning in developing conceptual understanding. Since students were given chance to share ideas with each other in the groups and try to defend their ideas towards other group members, they started to think about the concepts in detail. This contributes to their conceptual understanding.

> "Jeffrey Froyd, Nancy Simpson states that in the collaborative learning environment, the learners are challenged both socially and emotionally

> as they listen to different perspectives, and are required to articulate and defend their ideas. In so doing, the learners begin to create their own unique conceptual frameworks and not rely solely on an expert's or a text's framework. Thus, in a collaborative learning setting, learners have the opportunity to converse with peers, present and defend ideas, exchange diverse beliefs, question other conceptual frameworks, and be actively engaged." (FI_G8_CAY, ILP)

PSTs (n=33) also considered the disadvantages of cooperative learning while deciding to incorporate it in their lesson plans. The disadvantages mentioned for cooperative learning showed similarity to the disadvantages of argumentation. Therefore, they tried to find solutions to these disadvantages in a similar vein. Differently, PSTs mentioned the possibility of problems that may be caused from the grouping in cooperative learning.

> "On the other hand, set up the group and control their working is difficult, also classroom management problems can occur." (FI_G2_BK, ILP)

> "In cooperative learning, some students may not participate in the group work. Also, arranging groups can be problematic (time lose and so on)." (FI_G1_MK, ILP)

> "To set up the groups and the following works of groups requires careful management by the teacher." (FI_G4_SNA, ILP)

> "Classroom management will be difficult. Chaos may occur when making group process. Time is limited. Dominant students may press shying ones. Student may be out of topic." (SI_G3_AFE, ILP)

> "If groups are not constructed in a plan, in class chaos may occur" (SI_G2_ET, ILP)

In order to prevent these problems that can be caused from grouping, PSTs clearly explained teacher and student role in this process. Some of the PSTs assigned roles to the students and asked them to do search considering their roles.

> "Cooperative learning because I want students to come together to discuss that socio-scientific issue considering their roles given to them; doctors, psychiatrists or patients and relatives. That will increase their individual empowerment and intellectual development like critical thinking and decision making since they will be in interaction with their peers and communicate face-to-face to come to a common decision." (SI_G7_IT, ILP)

The PSTs decided to use the reverse jigsaw approach also assigned different roles to the individuals in groups. After the first discussion, students were expected to work collaboratively to produce claims and searched for evidences in their expert groups. Then, these groups were asked to share their knowledge with the whole class instead of coming to their original groups.

> "In this lesson, "The Reverse Jigsaw Approach" technique will also be used. This variation was created by Timothy Hedeen (2003). This technique differs from the original Jigsaw during the teaching portion of the activity. In the Reverse Jigsaw technique, students from the expert groups teach the whole class rather than return to their home groups to teach the content." (SI_G4_KD, ILP)

Other than roles for specialization in research, PSTs ensured that group members take active roles to share the responsibility. For this purpose, they planned to ask students to select writer or speaker. Moreover, PSTs planned to warn students to take active role in research by also using their smartphones and tablets so that each group member can contribute to the evidences found for their claim. According to the foundations of cooperative learning, groups' achievement depends on the contribution of each group members. Thus, PSTs tried to ensure active participation of each students in their group work.

> "Students access the information on their own by talking with their groupmates. According to Kim J Hermann in cooperative learning students encourage and help each other to reach their common goals, students give each other feedback, students challenge each other' conclusions and reasoning and students take the perspectives of others to better explore points of view." (FI_G1_BK, ILP)

> "Students are expected to do some research on the Internet and find some evidences for their claims. Moreover, they discuss in the groups and write the ideas on Google Doc. Then, they will select one person in order to present their ideas in front of the class. Finally, they will reach an agreement considering the whole ideas discussed in the class." (SI_G7_HK, ILP)

In order to ensure active participation of each student, teachers have some responsibilities. PSTs mainly were aware of their responsibilities in facilitating group formation and monitoring their progress throughout the completion of the task. Therefore, they included what they will do for this purpose in their lesson plans. They were aware that if they do not have a grouping plan, they may face some problems during grouping or the group dynamic may cause problems while students are working in their groups. Therefore, they mentioned the grouping procedure and criteria in detail in their lesson plans. In order to prevent time loss and chaos in classroom, PSTs mentioned clear directions to be given to the students while grouping.

> "In this lesson, students will make discussion and create their arguments and work in groups. So it is provided by constructing group by distributing students colorful envelopes including small paper that includes the name of group like public opponent and also will include the location of group at the back side of paper. In this way, any problem will be prevented and after constructing groups students works cooperatively and share their ıdeas and claims and evidences." (SI_G2_ET, ILP)

Moreover, in order to increase the potential of learning from each other and prevent the dominant groups in classroom decision making, some PSTs preferred to form heterogeneous groups in terms of achievement level, sex or other characteristics.

Since PSTs considered cooperative learning as a student-centered instructional strategy, they focused more on student role rather than teacher role also in their group lesson plans. Although three groups from the first implementation did not mention, other groups clearly explained the role of students in cooperative learning as in the following quotation.

> "In cooperative learning, each of the students has their own role, one of them is writer, other is speaker, etc." (SI_G5, GLP)

Two of the groups (n_{FI}=1, n_{SI}=1) also clearly explained the added value of technology in terms of facilitating students' role during the activity. They mentioned how students will make use of technology while they are participating in the activities.

> "With the colors given the group members are selected and as a small group they will work on. There would be a writer in the group but they search evidence to their claim together. They can use their mobile phones to use the blog given individually but they should write down their evidences as a group to one drive document." (SI_G2, GLP)

About teacher role, PSTs gave more specific information in individual lesson plans as compared to the group lesson plans. One of the PSTs clearly defined the facilitator role of the teacher by referring to the literature:

> "According to Roger and Johnson (1988), in cooperative learning, teacher,
> - Select a lesson.
> - Make the following decisions: i. Select the groups' size most appropriate for the lesson, ii. Assign the students to groups. For a variety of reasons, heterogeneous groups tend to be more powerful than extreme homogeneity, iii. Arrange the classroom. Group members need to be close together and facing each other, and the teacher as well as members of other groups need to have clear access to all groups. Provide the appropriate materials.
> - Explain the task and cooperative goal structure to the students.
> - Monitor the groups as they work.
>
> Therefore, teacher is like a facilitator." (FI_G4_EG, ILP)

The role of teacher in cooperative learning is vital in terms of differentiating it from any other teamwork. According to Ferguson-Patrick (2016), teacher's cognitive, affective, social and organizational roles are crucial to assist students effectively in developing social skills, transferring responsibility of learning to the students. Cognitive role of teacher in cooperative learning includes task linking, structuring and analyzing; and affective role includes consideration of feelings and encouraging students to make activity fun, social role is about helping students share ideas and be involved in actively. Lastly, organizational role includes organizing learning process by allocating roles or distributing materials etc. (Ferguson-Patrick, 2016).

Based on this description about teacher role in cooperative learning, only one of the groups from the second implementation mentioned teacher role by referring to these categories of role except affective role as it was given below. None of the groups wrote something about affective role of teacher. Groups were also deficient in writing objectives in affective domain.

> "In cooperative learning, teachers' role includes making pre instructional decisions, explaining the instructional task and cooperative structure and monitoring students' learning… Firstly teacher decides on the size of groups and how to use, arranges the materials according to students' needs, and teachers observe students' behaviors and social skills to understand that how each student works on groups... These

teachers can encourage students to consider about the topic with appropriate inquiry technique." (SI_G7, GLP)

In group lesson plans, about half of the groups (4 out of 9) did not mention the role of teacher. Two of the groups mentioned briefly that teacher should be facilitator. Only three of the groups gave details about the role of teacher by mentioning cognitive, social or organizational roles (Ferguson-Patrick, 2016). In individual lesson plans, 42 PSTs out of 47 mentioned the role of teacher in cooperative learning. Only four of the PSTs from the first implementation and one of the PSTs from the second implementation did not refer any of the cognitive, affective, social or organizational roles of the teachers. They stated only that teacher should facilitate cooperative learning activity. Again, from the first implementation three PSTs mentioned only one category of teacher role. They mentioned either structuring the tasks, ensuring involvement of students or allocating roles to students.

In the second implementation, most of the PSTs mentioning teacher role (12 out of 16), and gave detailed information about three categories of teacher role. One of them even mentioned the affective role of teacher that is commonly ignored role of teacher in cooperative learning as in the study of Ferguson-Patrick (2016). In implementing affective role, teacher should consider students' feeling that arise during cooperative learning task and need to encourage students, make the activity fun and worthwhile. This PST also focused on the role of teacher for encouraging students by mentioning the importance of their group work so that help them to think that it is worthwhile to participate in the task.

> "The teacher will walk around the class to observe groups' works. While walking the teacher will warn those who do not write any statement to the online table and discussing a subject irrelevant to their roles. Moreover, s/he will help the students to provide coherent and consistent answers for their claims by showing some critical points students are likely to disregard. Finally, s/he can restate the importance of their discussion in contributing to the collective decision making of the classroom. Their thoughts as in their roles are important to inform other."(SI_G7_IT, ILP)

As it can be inferred from the lesson plans, PSTs started to think about the teacher role in cooperative learning in detail in their individual lesson plans. Moreover, they were aware of the advantages and disadvantages of the instructional strategy. Being aware of the affordances and constraints and the way to facilitate students' cooperation, PSTs selected more functional technologies to reach their aim. In selecting technologies, they mostly mentioned the added value of the technologies in fostering their instructional strategy.

4.2.1.2. Questioning

When group lesson plans were analyzed it was found that almost all (n=13) of the groups employed and mentioned questioning in some parts of their lesson plans, although seven (n_{FI}=4, n_{SI}=3) of them stated it as one of their instructional strategy. Among these seven groups, only one of them provided a description of what they mean by questioning. None of the groups except for the eighth group of the first implementation and the fifth group of second implementation emphasized the role of students. Those groups stated that students only have the responsibility to answer the questions asked by teacher.

Similarly, groups did not explain the role of teacher in questioning except four groups (n_{FI}=2, n_{SI}=2). While explaining the role of teacher, groups mentioned different purposes of using questioning. Eighth group of the first implementation stated that teacher should ask meaningful question to develop students' thinking skills, while the third group of the first implementation stated the teacher role as attracting student and motivating them to involve in discussion through questioning. The groups from the second implementation preferred to use questioning for enriching their direct instruction at the beginning of their teaching as they stated in the following quotation. While explaining their SSI context to the students, these groups use questioning to learn what they know about the issue or to learn whether students understand the proponent and opponent ideas about the SSI mentioned in the shown video.

> "In questioning method, teacher addresses the relevant questions to the topic to learn about background knowledge and thoughts of the students. Teacher is in the role of data collector and students are source of data." (SI_G2, GLP)

As it was mentioned, although other groups did not explain questioning as one of their main instructional strategy, most of the groups stated their planned questions and expected answers. When the quality of the questions that were planned to ask were examined, almost all of the questions can be classified in the 'knowledge' level of Bloom's taxonomy (Dalton & Smith, 1986). They mostly asked questions to students that require definitions of concepts or examples to the situations. Even the questions of the groups who stated the responsibility of teachers to ask questions for developing thinking skills and for evaluating student understanding is in the knowledge level as in the following quotations.

> "Can you give an example of biotechnology which is included in your daily life?" (SI_G7, GLP)
>
> "Do you know whether there are other kinds of energy resources instead of fossil fuel?, Can you predict the names of these sources?" (FI_G8, GLP)

Among the written planned questions, only a few questions require higher levels of thinking. For example, the following question has potential to lead students to analyze the problem and try to think about the underlying reasons of the problem. So that it can be classified under 'analysis' level based on Bloom's taxonomy (Dalton and Smith, 1986).

> "Teacher says that 'Midway Island is far more than 2000 miles from the nearest continent. How would these birds find and eat these plastics then?'
> Student will answer 'Somebody may throw away those plastics.' Teacher says 'But there is no people living that island and it is very far. Then, how would these trashes come to the island?'. Students say 'Trashes in the ocean come to island with sea waves.'" (FI_G3, GLP)

Questioning was mostly preffered for assessment. They mainly planned to use questioning to assess students' knowledge about the topic.

> "Then, students give their opinion about what they learned from video which is related to GMO's. As a result of this, s/he will measure whether or not they learned." (FI_G2, GLP)

One of the groups stated that they would determine whether students are aware of all arguments about the issue.

> “That is, she asks all students questions about the topic and pro and con-arguments. She measures the knowledge of students whether they are aware of the pro or con-arguments of all groups and what they thinking about this issue.” (SI_G2, GLP)

Similarly, one group wrote some questions to be asked for formative assessment including the questions about the quality of the arguments and students’ ability to produce claims and justify their claims with evidences. Therefore, they focused on the assessment of quality of students’ argumentation.

> “Teacher usually asks questions to check students’understanding. For instance, how do you support your ideas about chemical fertilizers should be use or not? What could be your evidences to refute opposite ideas? How do you develop your ideas? You should improve your claim by considering opposite sites. Have you ever thought that the environment we live in is changing? Did you observe any changes from environment that you live in? etc. By the way, the answers of these questions also imply that whether her objectives and teaching performance are obtained.” (SI_G5, GLP)

Although two groups stated that they are planning to use quiz for formative assessment, they did not provide any detail when and how this quiz would be applied. Neither did they mention what they are planning to assess.

PSTs had more clear rational for using questioning. They explained the role of questioning in facilitating argumentation. PSTs mostly utilized questioning to reveal students’ background knowledge or to draw students’ attention to the topic as one of them stated in the below quotation. Therefore, they aimed to increase students’ engagement in argumentation.

> “At the beginning of the lesson, I will use “questioning strategy” to stimulate students’ interest and motivate participation” (FI_G6_BE, ILP)

PSTs also explained how they will utilize questioning strategy to encourage students to participate in argumentation activity. By asking stimulating questions about finding evidence for their claims or clarifying justification and so on, they tried to help students progress in discussion.

> “Questioning method will help me to bring their prior knowledge into the lesson. How? By asking driving questions during initiation part, they will remember their prior knowledges and past experiences. And when I ask questions like ‘What do you think about this aspect / You said that but what about this / Do you have reliable evidence/ etc’ they will elaborate their thinking and express themselves better. (But with those questions, I will not direct or affect their thinking, I will just let them think about different aspects.)” (SI_G5_NFO, ILP)

A few PSTs mentioned that they selected questioning strategy to elicit students’ misconceptions.

> “I use questioning in the direct instruction because teacher can learn the student’s background knowledge and misconceptions. Teacher teaches the lesson according to student’s answer. For Example, students have misconceptions or misunderstanding, first teacher fix these then teach the topic.” (SI_G2_DB, ILP)

Similar to the group lesson plans some of the PSTs did not mention questioning as one of the main instructional strategy, athough they used questioning in different parts of their lesson plans. Although 24 PSTs mentioned from questioning as one of their main instructional strategies, 49 of the PSTs included questions planned to be asked and the expected student answers in the lesson flow. The questions planned to be asked were congruent with their purpose of using the strategy. The questions were generally asked to encourage students to talk about their previous experiences or previous knowledge about the SSI topic.

> “What do you do when you are sick? Do you have medicine for being healthy? What do you think about how the medicine can be tested before we take it?” (FI_G8_AD, ILP)

Moreover, they included some activating questions into the lesson flow to facilitate argumentation.

> “In the discussion part, these questions are planned to be directed to students: ‘Which idea do you agree with? (Organ Donation should be required/ or not)’ ‘Why do you think so?’ ‘Would you provide evidence to support their claim?’ ‘Why don’t you agree with other claim?’ ‘What are the advantages of organ donation?’ ‘What are the disadvantages of organ donation?’” (FI_G6_BE, ILP)

Some of the PSTs' questions were so diverse that facilitate students to think in multiple perspectives. By guiding students with such questions, PSTs aimed to help their students to reach the fourth level in argumentation, rebuttal. One of the PSTs adapted the interview questions provided in Sadler and Zeidler's (2005) study to foster her students' informal reasoning in different patterns. PSTs stated that with the help of questions, they were planning to collect information about their student' thinking patterns and learn their rationales in decision-making. To sum up, the stated reasons for implementing questioning strategy and the stated questions intended to be asked during the lesson indicates that PSTs were knowledgeable about SSI teaching and argumentation. They utilized this strategy to facilitate the implementation of argumentation.

Moreover, PSTs planned to take advantage of some technological tools, especially multimedia tools like impressive pictures or videos, to initiate questioning and to overcome some disadvantages of questioning strategy. For example, according to PSTs, it is difficult to motivate students to answers the questions. To arouse their curiosity or catch students' attention, PSTs planned to use technological tools to complement their questioning.

> "In order to remind previous lessons and reveal possible misconceptions about nutrients, content of nutrients and their basic functions, s/he asks questions with the help of pictures (at this point, teacher uses power point presentation consisting of pictures and questions in order to raise students' curiosity)" (FI_G1_BK, ILP)

To sum up, PSTs utilized questioning strategy in their both group and individual lesson plans. Some of them did not gave definitions of other details about questionin as instructional strategy. However, almost all of them included questions planned to be asked and expected student answers in their lesson plans. When we compare individual lesson plans and group lesson plans, PSTs had more clear purpose for using questioning for argumentation in their individual lesson plans. As it can be inferred from their explanations about questioning in their individual lesson plans, by observing SSI teaching performances and practicing SSI teaching, they developed an understanding about how questioning can contribute to SSI teaching and how necessary it is to facilitate argumentation.

4.2.1.3. Direct instruction, discussion and others

Although they are not frequently selected instructional strategies, discussion (n=16), direct instruction (n=12), 5E (n=4), online scaffolding (n=5) and role playing game (n=2) were other selected instructional strategies in individual lesson plans. Similarly, being relatively less frequently selected instructional strategies compared to previously mentioned instructional strategies, discussion, direct instruction and 5E were other selected instructional strategies in group lesson plans.

Two groups (n_{FI}=2, n_{SI}=1) selected discussion as an instructional strategy to help students be engaged in argumentation in the context of SSI. The third group of the first implementation also planned to use discussion, although they did not have the goal of engaging students in argumentation. Only the seventh group of the first implementation explained what discussion referred to in their lesson plan. While defining discussion, they emphasized the role of it in engaging students in argumentation as in the following quotation.

> "Group discussion will be used in this lesson. According to Raddy discussion is a thoughtful consideration of relationships involved in the topic or the problem under study. These relations are to be analyzed, compared, evaluated and conclusions are drawn (2008). Discussion is an activity which a person join in an argumentation about a topic. In discussion participants want to arrive at some conclusions." (FI_G7, GLP)

Sixteen PSTs decided to implement discussion in their individual lesson plans. They planned to use discussion to provide a medium for sharing ideas within and among the groups. It was used as a complementary strategy in implementing argumentation. The main purpose for using discussion was stated by one of the PSTs as:

> "Discussion is used for sharing idea in the group and supporting that, listening each other, explaining the situation in which students support or not." (SI_G1_AO, ILP)

Almost all of the PSTs emphasized the importance of discussion for helping students to see multiple points of views. This is one of the important characteristics of SSI pedagogy that SSI teaching practices should include examining issues from multiple perspectives (Sadler et al., 2007). Most of the PSTs mentioned the advantages of discussion similar to the following:

> "- Makes students active in learning process. - Allows students to see different points of view and develop their knowledge and opinions. - Leads students to learn from each other and they learn from each other effectively. - Improves decision making skills of students and encourages critical thinking." (SI_G1_CU, ILP)

Moreover, three groups (n_{FI}=1, n_{SI}=2) wrote direct instruction as one of their instructional strategy, although most of them used direct instruction at some point in their teaching. Groups selected this instructional strategy to give information about their SSI context in short time. They were aware of the disadvantages of the strategy like losing attention, leading to memorization, and not fostering higher order thinking skills. Two of the groups in the second implementation clearly defined what they mean by direct instruction as in following quotation:

> "It is an instructional approach that are structured, sequenced, and led by teachers, and/or the presentation of academic content to students by teachers, such as in a lecture or demonstration." (SI_G2, GLP)

Third group of the first implementation only gave information about the teacher role in direct instruction. They declared that by showing pictures and asking questions in direct instruction they expected to develop students' higher order thinking skills like problem solving and decision-making skills.

By considering the ineffectiveness of this instructional strategy in terms of arousing and keeping attention, the first group of the second implementation defined teacher role as presenting information to the students as well as using posture and gesture effectively and being energetic to prevent attention lost. Moreover, they stated in their plans to utilize technology to make direct instruction more motivating by including visualization tools.

In individual lesson plans, twelve PSTs planned to use direct instruction to give information about the topic. They planned to use this instructional strategy at the beginning of the lesson. In order to increase the quality of discussion and argumentation, PSTs planned to complete the deficiency of students' background knowledge.

> "At the beginning of the lesson, I use direct instruction because students do not know much information about this issue .therefore; teacher gives some information about the topic of the lesson directly." (SI_G2_DB, ILP)

Since they think that both argumentation and cooperative learning are time-consuming instructional strategies, they did not want to lose time for giving required background knowledge about the topic. Therefore, they preferred to use direct instruction for this purpose to save time.

> "In this way students directly gets main concepts about topic like renewable or non-renewable resources or nuclear energy without consuming time." (SI_G2_ET, ILP)

In addition to these commonly mentioned instructional strategy, some of the groups utilized unique instructional strategy. For example, the seventh group of the first implementation utilized 5E instructional strategy in teaching their SSI topic. They were quite knowledgable about 5E instructional strategy. They prepared a blog so that teacher would guide students about the process to be followed through the instructions embedded in the blog. They clearly explained what they expected from students to do and described their roles in this process. Moreover, the role of technology in facilitating these processes was detailed in their lesson plan. This group mentioned the role of blog in this process with another instructional strategy, which they called web-based educational scaffolding as it was given below. Acknowledging the role of teacher in web-based educational scaffolding, they tried to fulfill their duties by preparing an effective blog that is useful for scaffolding.

> "Scaffolding is another strategy which will be used. Since it is a new term for teacher, there is no dictionary definition, however according to Jamie McKenzie there are eight characteristics of web-based educational scaffolding: clear directions, clarifying purpose, keeping students on task, offering assessments to clarify expectations, pointing students to worthy sources, reducing uncertainty, surprise and disappointment, delivering efficiency, creating momentum (2000). In this class we will use scaffolding while we are conducting lesson plan." (FI_G7, GLP)

The members of the seventh group of the first implementation utilized 5E and online scaffolding instructional strategies also in their individual lesson plans. They adapted their group lesson plans to another topic in their individual lesson plans. They were already knowledgeable about these instructional strategies. Moreover, they successfully utilized technology in a way that facilitates their implementation of the instructional strategies in their group teaching performance. Therefore, based on the feedbacks they took from the instructor, they decided to use the same instructional strategies in a similar vein.

Overall, PSTs used variety of instructional strategies to teach SSI topics through argumentation. Although most of them do not have enough declarative (what is the teaching strategy), procedural (how can the strategy be used) or conditional (why it is a useful strategy) knowledge about the instructional strategy they used, some of them clarified all points about the used instructional strategy showing their awareness about the instructional strategy.

To sum up, although variety of the instructional strategies that PSTs selected for individual lesson plans was not increased as compared to the group lesson plans, they started to make more purposeful selection. They were quite knowledgeable about the elements, advantages and disadvantages of the instructional strategy they selected. Moreover, they shaped the flow of their lesson plan by using their knowledge about the expected teacher and student role in the selected instructional strategy. All of the PSTs implemented argumentation to teach SSI in accordance with the literature. They selected other instructional strategies to smooth their implementation of argumentation strategy. Their theoretical and practical knowledge about the planned instructional strategies seemed to be more complete as compared to the group lesson plans.

4.2.2. Facilitation of argumentation about SSI through technology

PSTs mentioned the advantages and disadvantages of the selected instructional strategy in their group and individual lesson plans. They also mentioned that they would utilize technology to overcome the disadvantages of the instructional strategy and to facilitate their implementation of argumentation. Therefore, in this section, PSTs' technology usage plan in a way that enriches their use of instructional strategy was explained. Whether the selected technologies and the way PSTs integrate them was congruent with the requirements of the instructional strategy was discussed.

When their group lesson plans were analyzed, it was figured out that they selected a variety of technological tools to be used by teachers and/or students (Table 15). PSTs planned to use different technologies for different purposes to facilitate their implementation of argumentation. Most frequently used technologies in group lesson plans were multimedia tools, presentation tools, online communication tools, online assessment tools and cloud storage tools.

Table 15
Technological Tools Planned to be Used to Facilitate Argumentation

Technological tool	Number of PSTs selected tools for teacher use				Number of PSTs selected tools for student use			
	GLP		ILP		GLP		ILP	
	FI	SI	FI	SI	FI	SI	FI	SI
Multimedia tools	17	9	25	26	-	-	5	2
Presentation tools	2	9	8	29	-	-	-	1
Online communication tools	3	6	9	25	2	9	11	32
Online assessment tool	1	4	3	18	1	5	2	12
Cloud storage services	2	2	19	15	3	5	21	26
Smartboard	1	2	5	7	1	-	-	8
Online game	1	-	1	-	1	-	1	-
Concept map program	-	1	-	-	-	-	1	-
Office word	1	-	2	-	1	-	2	-
Poll	1	-	2	1	1	-	2	1

PSTs also made use of technology to ease the implementation of their instructional strategy in their individual lesson plans. PSTs decided to use variety of technological representation to teach their SSI topic effectively.

Most frequently selected (n_{FI}=25, n_{SI}=26) instructional technology was stated as multimedia tools. Video (n_{FI}=17, n_{SI}=23) was the most frequently selected multimedia tool in both implementations. PSTs also planned to use animations (n_{FI}=3, n_{SI}=4), simulations (n_{FI}=1), and static images (n_{FI}=6, n_{SI}=4) for different purposes in different phases of their designed lesson. The other frequently selected instructional technology to be used by teacher in lesson was presentation tools. Teachers included the multimedia tools in their presentation. For presentation most of the PSTs preferred to use Powerpoint (n_{FI}=8, n_{SI}=22) while some of them planned to use Prezi (n_{FI}=2, n_{SI}=7) and Powtoon (n_{SI}=1).

PSTs also planned to use different online communication tools to facilitate the communication between students. They used variety of tools for this purpose. They preferred to use blog (n_{FI}=4, n_{SI}=15), Beyazpano (n_{SI}=15), e-mail (n_{FI}=2, n_{SI}=1), video conferencing (n_{FI}=1) and webquest (n_{FI}=1). In addition to these communication tools, PSTs also planned to utilize the cloud storage services to allow idea or file sharing. The tools selected for this purpose were OneDrive (n_{FI}=14, n_{SI}=3), Google Documents (n_{SI}=28) and Dropbox (n_{FI}=13). In addition to these frequently used tools, PST also planned to use smartboard (n_{FI}=5, n_{SI}=7), MS Office Word (n_{FI}=2), polls (n_{FI}=2, n_{SI}=1), online game (n_{FI}=1) and concept map program (n_{FI}=1).

There was a difference between the PSTs in different implementation in terms of using technology for the purpose of assessment. Three PSTs from the first implementation decided to use assessment tool, while the number of PSTs planned to use assessment tool was 15 in the second implementation. They planned to use different tools for this purpose including Kahoot (n_{SI}=12), classdojo (n_{SI}=3), Edmodo (n_{FI}=2 I), classmarker (n_{SI}=1), quizlet (n_{SI}=1), socrative (n_{SI}=1), survey monkey (n_{FI}=1), C+ program (n_{SI}=1). As it can be seen more PSTs planned to use presentation, online communication and online assessment tool in the second implementation.

In order to understand how they will use these technologies to facilitate argumentation, they were also prompted to explain the rationale for their technology usage. PSTs stated different reasons for selection of technology in their lesson plans (Table 16). General categories for their rational for using technology were giving information, allowing communication, searching, managing the classroom, visualizing, motivating and assessment.

Table 16
PSTs' Technology Integration Strategies to Facilitate Argumentation

Category	Codes	Groups lesson plans		Individual lesson plans	
		FI	SI	FI	SI
Allow searching	To understand the issue	4	3	22	17
	To find evidences	3	2	17	14
	To produce claim	3	2	5	6
Visualization	To make concepts and phenomena concrete	3	7	17	16
	To facilitate learning of students with visual intelligence	2	3	8	10
	To increase retention	1	1	2	9
Give information	To show multi-perspective nature of SSI	-	5	8	31
	To share resources	-	5	-	28
	To introduce concepts related to the issue	1	4	8	17
	To remind previous knowledge	-	-	7	6
Motivation	To excite attention	5	5	18	23
	To develop empathy	1	3	4	4
	To arouse curiosity	-	1	3	1
Communication	To allow idea sharing	3	4	7	6
	To make all arguments visible to classroom	1	-	6	11
	To facilitate students' rebuttal for counter-arguments	-	2	5	12
	To allow synchronous communication	1	3	26	24
Classroom management	To accelerate the search	2	5	10	15
	To monitor students' ideas	1	2	4	11
	To accelerate the discussion	1	1	8	3
Assessment		1	6	15	31

4.2.2.1. Allow searching

In group lesson plans, the most frequently stated reason for technology selection was allowing students to do search about the SSI topic. The frequencies of this category were about the same for the groups of both implementations. All of the groups acknowledged the vital role of integrating technology in helping students for informed decision-makings by allowing them to do search to understand the issue, to produce their claims and to find evidences as in the following quotations.

> "Moreover, without technology using, students cannot find evidence to support their idea" (FI_G1, GLP)

> "The topic discussed is a socio-scientific issue and it is a current topic. Students may not be too much knowledge on the topic, because of that making research on the internet is very useful for obtain the broad information about the issue." (FI_G6, GLP)

> "The goal of using technology is also important. For example, we will use the blog to help the students for their research." (SI_G2, GLP)

Alowing students to do search was also one of the most frequent strategy of technology integration to facilitate argumentation in individual lesson plans. PSTs planned to ask students to do search for different reasons. One of these reasons was helping students to learn the topic well. As it was explained above, in the first implementation, PSTs were not devoted time for explaining or teaching the scientific concepts related to the issue. Therefore, PSTs expected from their students to find scientific articles and learn the concepts well through searching.

> "Internet usage students construct their own knowledge by searching in online and safe web sites." (FI_G8_AD, ILP)

> "Searching and finding different academic sources will make them improve their knowledge about cloning." (FI_G2_SUA, ILP)

PSTs also planned to ask students to do search to learn about the arguments related to the SSI topic so that they can easily construct their own claims.

> "In the scope of this lesson, a socio-scientific issue will be handled. Students may be heard some information about the issue before, but this information will not be enough for making a class discussion or looking a certain perspective to the issue. So, the computer with internet connection must be provided for such activities. Students reach a lot of information about the issue on the internet and the information contributed to them creates a frame about the issue". (FI_G6_RO, ILP)

> "But all of them should have an opinion to form their cons or pros argument or to support their claim and searching through technology can help them at this way, for example." (SI_G2_EO, ILP)

PSTs also expected from their students to do search to find evidences to support their claims. They either planned to provide links to be investigated or to ask students to find relevant sources on the internet by themselves.

> "By the help of the blog page, pupils can reach different evidences and sources about the usage of the nuclear energy in the world and they can

> have a better understanding of benefits and harms of the nuclear energy." (SI_G6_MCO, ILP)

4.2.2.2. Visualizing and giving information

Groups planned to use different multimedia tools like video, picture, animation, simulation etc. for visualization to make abstract topics concrete, to facilitate learning of the students with visual intelligence and to increase the retention of the learned concepts.

Groups also planned to use different technological tools to show students the multi-perspective nature of SSI by explaining the claims of the different perspectives of the issue and to introduce the scientific concepts regarding the issue with technological tools. Moreover, they planned to share resources with students to help them make research.

The groups in the second implementation used technological tools for visualization and giving information to students more as compared to the groups in the first implementation, due to the changes in the course. In the second implementation, additional 30 minutes was devoted to the groups' teaching performances for initiation of their SSI teaching. Therefore, they taught SSI to their students in two consecutive weeks. In the first week, they were expected to give necessary background information to their students about their topic. Therefore, they had more chance to give information with variety of visualization tools about the scientific concepts or the arguments related to their SSI topic.

Visualizing was also one of the main reasons of PSTs for using technology as stated in their individual lesson plans. PSTs decided to use different technological tools to visualize for different reasons. Mostly, they preferred to use visuals to make abstract topics concrete. They tried to make either scientific concepts or the SSI topic concrete.

> "Gene cloning can be abstract concept for students. They can have difficulty in understanding the processes of this socio-scientific issue. By the help of the technology such as video, simulation, it will become more concrete." (FI_G2_AK, ILP)

> "Students may not understand cloning clearly. In order to make it more concrete, teacher will use technology. She/He will use a simulation called 'click and clone' so that student can understand the cloning easily." (FI_G1_SKO, ILP)

PSTs also planned to use visual tools to address students' need with different intelligence types.

> "By showing videos students with visual intelligence can learn the content better and because the videos have all information that students should know, it helps students to classify the features of biofuels and fossil fuels" (SI_G6_OU, ILP)

By making abstract topics concrete and addressing different students' needs through technology, PSTs aimed to increase the retention of the learned topics.

> "The students can understand the topic easily by using technology. Because the technology using is enjoyable for students. Thanks to the animation and pictures, the topic can be easy for the students. The topic is remembered easily via technology." (FI_G7_DB, ILP)

Giving information was the most frequently stated reason for technology integration into SSI teaching in individual lesson plans. PSTs gave importance to giving information to the students, because if students do not have necessary knowledge about the issue or the scientific concepts related to the issue, the argumentation cannot be effective. As it was explained in case-based issues, PSTs had concerns about whether the lack of scientific knowledge interferes with students' engagement in classroom discourse. Therefore, with the presentation tools, videos or news, PSTs aimed to show students the scientific information and multi-perspective nature of SSI. They tried to explain different perspectives regarding the issue to students.

> "The video is also essential because it gives almost all proponent and opponent ideas with a background music. Stating directly these ideas does not run effectively. The video has an animator and pictures about each idea. In a kind of issues, summarizing the advantages and disadvantages of content with a video is a good and effective idea." (SI_G8_MM, ILP)

Moreover, PSTs planned to give information about the issue to the students by sharing resources. Some of the groups argued that their teaching was not effective due to students' difficulty in searching for evidences. For example, the first group of the first implementation said that the students had difficulty in research, because they could not find proper resources.

> "FI_G1_SKO: since students were not prepared, they had difficulty in deciding which resources they should use. For example, they were searching for human effect on global warming. They found a website including all of the argument. They had difficulty in selected relevant arguments." (SI_VSRI_G1)

To oversome this problem, the effective groups shared the proper resources with students. They provided links for students and asked them to search from these resources and use other resources in case of need.

One of the effective groups from the second implementation also emphasized the contribution of their resource sharing on their effectiveness. They said that leaving students alone in searching is not an effective way.

> "SI_G6_DC: If we asked students to search by themselves, they would not search effectively. Even we can find resources hardly." (SI_VSRI_G6)

Therefore, it can be inferred from the groups' reflections that in order to increase the quality of students' research, searching and sharing appropriate resources can be an effective strategy. For this reason, they designed blogs or other online communication platform and embedded the links in it. Thus, students were expected to search these links and reach the information about the topic.

> "Moreover, blog can have pros and cons of usage of food additives from articles science students can reach knowledge easily and create own claim and find evidence."

In order to increase the quality of the argumentation, PSTs tried to help students learn the scientific concepts required to understand the issue. Different from the group lesson plans, PSTs also aimed to help students remember their previous knowledge with technology in their individual lesson plans. For these purposes, PSTs planned to use presentation tools or multimedia tools.

> “In addition, with this video, teacher helps students to gain the idea about what gene cloning is before the discussion part because if students do not know and enough knowledge what gene cloning is, they cannot participate the discussion effectively.” (FI_G2_AK, ILP)

> “I will use the powerpoint for recalling the previous knowledge” (SI_G8_EAC, ILP)

A difference can be observed in this category for two implementations. More PSTs from the second implementation planned to give information through technology before starting to the discussion. This can be related to the changes in the implementations as it was explained above. Since in teaching performances, the groups in the second implementation were given extra time for giving information, this difference might also affect their individual lesson plans. Since PSTs from the first implementation were not devoted time for giving information, they planned to meet the deficit by allowing PSTs to search for learning the topic as it was explained below under search category.

4.2.2.3. Motivating

Another main reason for technology use was stated as motivating students. By exciting attention to the topic, arousing their curiosity and helping students to think from different perspective and develop empathy, groups planned to increase the motivation of students for learning SSI topic.

With the help of different technological tools, PST also planned to motivate students in their individual lesson plans. PSTs stated that using technology could excite attention, since the planned technologies were attractive and enjoyable. With technological tools, PSTs planned to help students to learn in an enjoyable way.

> “Teacher use technology to attract students’ attention. Thanks to technology, lesson will be more enjoyable and interesting. In addition, students be familiar socio-scientific issue by using technology.” (FI_G4_EA, ILP)

Moreover, with the videos explaning the arguments of different stakeholders, students can have opportunity to think from their point of view. Thus, PSTs planned to develop empathy in students.

> "They can feel responsible about the issue. They can think that they also a citizen and they make research about socio-scientific issue. Then, they can decide about a socioscientific issue by writing their ideas to the one drive." (SI_G2_DB, ILP)

By showing interesting videos and giving news from daily life, PSTs planned to arouse students' curiosity.

> "To be understand issue easily, I will show the news from the internet. It also increases the curiosity and makes issue more understandable." (FI_G8_CAY, ILP)

To sum up in both group and individual lesson plans, PSTs planned to get profit from technological tools to increase students' motivation. By exciting attention, developing emphaty and arousing curiosity, they aimed to constibute to their motivation.

4.2.2.4. Communication

According to the groups' rationality for technology selection given in lesson plans, they preferred technology also for allowing communication among students and between teacher and students. To enhance the communication, groups selected online communication platforms to guide students in argumentation process. For this purpose, mostly blogs were preferred in group lesson plans. Moreover, one of the groups preferred to use skype to enable communication between guest expert and the students. Then, one of the groups planned to use webquest to trigger the discussion in classroom. This webquest was planned to include five parts, which are introduction, task, process, evaluation and conclusion. One of the groups planned to use a social networking service, Facebook, for online communication to collect students' evidences easily and provide an environment for immediate idea sharing.

Groups' selection of technology was affected from the foundations of teaching with argumentation. Therefore, they decided to use technology to allow idea sharing among students, to make all arguments visible to classroom, to facilitate students' rebuttal for counter-arguments and to allow synchronous communication as it can be seen below.

> "With the help of this program, they can easily read their friends arguments and their refutations and they can write answers to them. Therefore, they communicate each other easily and effectively." (SI_G1, GLP)

> "Beyaz Pano also gives chance them to see counter idea and students will learn that socio-scientific issues do not have true one answer or solution. They will learn that important thing is to support idea with evidences." (SI_G3, GLP)

> "While using argumentation strategy, using of online collaborative tools will help the teacher see each students' ideas at the same time." (SI_G5, GLP)

> "We use argumentation, questioning and scaffolding in this lesson to provide a controversial classroom environment. Because energy issue is controversial, they should form ideas and share their ideas in the class discussion. Thanks to selected instructional technologies we will provide this environment." (FI_G8, GLP)

At this point, the frequency of the code for the reason of communication showed difference between the groups of different implementation. The frequency of statements indicating idea sharing as one of the reason of technology usage was relatively more in the second implementation. Since PSTs in the second implementation had more clear view about the nature of SSI, they were aware of the need for idea sharing among students. Therefore, the need for finding ways to help students share ideas effectively with other students become a concern more for the groups of second implementation. As a result, they utilized technology to solve this issue as they stated in the following quotations.

> "Moreover, teacher uses "google documents" to collect the ideas of each group by the help of technology and to help students to have more healthy discussion environment and not to have conflict during the discussion." (SI_G6, GLP)

> "This content based on sharing ideas and opposite ideas, so it is so hard when it is on paper. They will think about the subject and find evidence and share online with writing. It cannot be on paper so technology usage is needed in this point." (SI_G4, GLP)

Communication was the next most frequently stated rational for technology usage stated in the individual lesson plans. Almost all of the PSTs planned to use technologies that allow students to share their ideas with the opponent groups. PSTs mostly grouped the students based on different roles related to the issue. Then, they divided these groups according to their position. Therefore, they formed groups including the opponents and proponents of an idea. These groups constructed claims from their own perspective and shared their claim with the opponent or proponent groups. Online communication tools or cloud storage devices was used by PSTs to allow students sharing ideas.

> "And also second week we start to make argumentation and during discussion they should use beyaz pano again to write their pro and counter arguments in their group page. So I will give new links and access codes to use beyaz pano groups part." (SI_G3_AFE, ILP)

Moreover, PSTs stated that by using technology, they would be able to help their students to see the counter arguments, respond to them and write rebuttals for those counter arguments.

> "By using Google Documents, students can easily understand the counter claims and write better rebuttals for these counter claims."(SI_G7_HK, ILP)

PSTs planned to use technology for its affordances in making all of the arguments from different perspective visible to the whole class. By sharing pair-groups' co-created argument files with the rest of the class or reflecting all of the claims from different perspective to the projector, PSTs aimed to help all of the students to be aware of all possible arguments from different perspectives.

> "Reflect groups of students' claims and ideas from my iPad to the smart board by using Wi-Fi projector. So, everyone in the class can see the sharing ideas equally with using the smart board." (FI_G6_BY, ILP)

> "Students will reach the other groups claims/ evidences and they will learn the groups' ideas not only opposite group but also all groups' ideas from the Google doc. That is to say that students' understandings related with the issue will be exhibited on the Google doc. because they will fill the frames according to their understandings from articles, presentation or their own knowledge." (SI_G5_HY, ILP)

Moreover, PSTs stated that they selected the particular technologies for its advantage on ensuring synchronous communication. Since the selected technology aimed to help students to share ideas at the same time, they can make research by seeing other group's counter-argument. Therefore, according to the PSTs' statements, argumentation would become meaningful and communication would become faster and easier.

> "Thanks to One Drive, students share their ideas and claims as online immediately. It supports the flow of the lesson." (FI_G4_EA, ILP)

To sum up, PSTs and groups used different communication tools to increase the quality of their implementation of argumentation. Through different effective tools students got chance to share their ideas with other easily, they could view all arguments so that understand the multiperspective nature of SSI. Moreover, by allowing communication between the groups who have opposite ideas, PSTs facilitated students' rebuttal skills. Through synchronous communication tools, PSTs managed argumentation in the classroom easily.

4.2.2.5. Classroom management and assessment

Groups stated that the use of technology was required to create the intended learning environment. They selected technologies to make argumentation more manageable. Therefore, another main category of technology selection strategy was determined as classroom management. By accelerating the search of students and the discussion, and monitoring students' ideas, they intended to save time. PSTs planned to use technology to save time. By using technology in a way that supports the implementation of their instructional strategy, they planned to gain considerable time to allocate for different activities.

> "In addition to this, students cannot understand the effects of human cloning without any sharing idea and we have to manage our lesson time in class, so we used webquest to fast the discussion and we wanted that students establish empathy with different occupational group to provide better understanding socio-scientifically." (FI_G5, GLP)

> "In using jigsaw method, students can send their ideas and conclusions from internet accesses, which will be given to each group, to mutual website, onedrivelive.com. So, teacher can easily show all of the results to classroom from his/her own computer and he/she gains time with it." (FI_G6, GLP)

> "It provides convenience for the teacher because she can gather the opponent and proponent ideas easily and shortly so she gains time for other activities." (SI_G1, GLP)

> "In activity part teacher also uses "wordpress" to provide evidences about their claims and some sources that they can get more information about the Yeşil Yol Project. In this page each group can find their evidences in related part and therefore it make it easy for them to find evidences for their sides and there will be no time consumption during this stage." (SI_G6, GLP)

By activating the entire classroom and allowing their interaction through technological tools, it was planned to increase the quality of argumentation.

> "Technology makes it easy to discuss such issues and have better oriented ideas with the evidences. Since socio-scientific issue needs whole class participation and opinions of each student when teacher uses technological applications that allow students to share and justify the ideas, the lessons that are done to teach socio-scientific issue should be well-integrated with the technology." (SI_G6, GLP)

> "Moreover students also can see what the other groups write on the table on internet and that makes communication faster and easier." (SI_G7, GLP)

PSTs also planned to use technology for its added value in terms of classroom management in their individual lesson plans. They mainly appreciated the advantages of technology in terms of helping to manage time effectively as in their group lesson plans. PSTs stated that with the help of technology students can easily do search, so they gain more time for discussion. They stated that without using technology for searching, students could not reach the necessary information in such a short time.

> "Using technology will prevent time consuming because it is easier than searching from books." (FI_G1_SKO, ILP)

Moreover, technology can help gaining time by providing an effective discussion environment. They stated that the blog, webquest or other communication platforms aimed to help students to discuss their ideas without time loss.

> "The discussion topic is argumentative issue nowadays so most of the students have any ideas for it. However, they must support them with any strong evidences and claim them clearly and they must use time effectively due to limited time for the discussion. To do this, they should use technological environment, like internet, drop box effectively." (FI_G8_EY, ILP)

> "For the argumentation, these technologies save time. Students do not lose time in comparison with writing on the board and so on." (FI_G1_MK, ILP)

> "We have to manage our lesson time in class, so I use webquest to fast the discussion." (FI_G5_RD)

According to the PSTs statements, in addition to preventing time consumption, technology use also helps teachers to monitor students' ideas. Since teacher can see students' ideas, they have opportunity to intervene if a need arises.

> "I choose One Drive application, because when students use it, I also reach same documents in this application and monitor what they write." (FI_G1_BK, ILP)

As it was frequently stated by PSTs in interviews and reflections, pursuing students' ideas during argumentation is one of the most difficult parts of SSI teaching. For this reason, using technology to help teacher see students' ideas increases the efficiency of argumentation. Therefore, PSTs preferred to use technology for this reason.

> "An online platform will be used during this activity for sharing ideas. By this way, every group have a chance to see other groups' ideas to making claims for supporting their ideas against other ideas before the class discussion and also the teacher carries out class discussion by looking students' ideas on this online platform." (FI_G6_RO, ILP)

> "I want students to discuss a socio-scientific issue on nuclear power plants should be constructed or not. I will divide students into 6 groups providing them computers and Google docs based tables to be filled by them. Thanks to these technologies I become able to see what students write to support their evidences as well as refute the opposing ones." (SI_G7_RA, ILP)

For the purpose of formative assessment, groups also stated different assessment methods. They planned to use, from most frequent to less frequent, observation, questioning, rubric, activity sheet, discussion and quiz. While some groups planned to use different method, some of them relied on only one or two method. One group did not plan to use any formative assessment method.

Almost all of the groups (n=15) planned to observe students while they are working in groups, so that they planned to assess students' progress. They typically stated that the teacher would walk around and observe students' progress.

> "Teacher will walk around the classroom to monitor their group work and their progress. If they have problems about any topic, teacher will help groups." (FI_G5, GLP)

Some of the groups planned to make observation of students' progress through technological tools.

> "We will see the answers from the scene (students send from the facebook group) and we will understand what they have learned and what they have done." (FI_G8, GLP)

> "We will use Google docs for detecting what are their arguments about subject and whether they compromise on a decision or not. And did they use the technology properly for discussion or not." (SI_G7, GLP)

Some of the groups planned more structured observation by using rubric. The seventh group who planned to implement 5E instructional strategy, planned to use rubric based on the expected student behaviors at each phase. Similarly, the first group of the second implementation included items related to the qulity of argumentation skills in their checklist. One group from the second implementation designed a tool for formative assessment. They wrote a simple assessment program in C+ to assess students. They assigned one of the group members for making observation and assessing students' performance with this program. Similarly, this group also assessed both students' progress in argumentation and in technology usage.

> "While students are discussing the topic, we assess them using a basic computer program written by us.
> The program includes the statement;
> - Everyone in group participates in the discussion.
> - Students in a group show respect to each other
> - Did students speak loudly?
> - Did students go off the subject?
> - How creative they think while producing the pro and counter
> - Everyone uses technology efficiently." (SI_G3, GLP)

Other groups stated to use activity sheet for more structured formative assessment. They designed an acitivity sheet to be followed by students during the activity. They stated that they would use the activity sheet to obtain data from students about their progress and decide the flow of the lesson. By observing whether students filled the parts of the activity sheet in the planned time, they planned to move on the next part.

> "Teacher will control each groups part by part. There is a worksheet, which students have to follow, when we used Beyaz pano. All parts of worksheet have limited time. Teacher will be sure that each groups finished recent part before passing others." (SI_G3, GLP)

Groups did not plan to utilize different technological tools for assessment. PSTs' assessment decisions showed similarity with the group lesson plans in terms of the focus of assessment type; however, they utilized technology effectively for the purpose of assessment in their individual plans. They preferred formative assessment more than diagnostic and summative assessment. 52 PSTs (n_{FI}=29, n_{SI}=23) mentioned that they used assessment methods for diagnostic purpose. Similarly, 59 PSTs (n_{FI}=28, n_{SI}=31) planned to use summative assessment. On the other hand, except 5 PSTs all of them (n_{FI}=35, n_{SI}=40) mentioned different assessment methods for formative purpose.

About diagnostic assessment, most of the PSTs planned to use questioning. In the first implementation, all of the PSTs except one stated that they would ask questions to the students to learn about their prior knowledge.

> "At the beginning, I will assess students' prior knowledge by asking questions." (FI_G4_EG, ILP)

Only one of the PSTs from the first implementation stated that she would use an online quiz prepared on the surveymonkey for diagnostic purpose. She also added the screenshot of the online quiz into the lesson plan.

Similarly, in the second implementation, PSTs stated that they would use questioning for diagnostic purpose.

> "To measure students as diagnostic I will ask them some questions before beginning this topic which is Human Genome Project. These

> questions will be oriented to understand their prior knowledge about the particular topic." (SI_G4_EAL, ILP)

However, contrary to the first implementation about half of the PSTs (n=12) stated that they would use quiz as the assessment method for diagnostic purposes. All these PSTs except one stated that they would make use of an enjoyable online assessment tool for this purpose. They used these quizzes not to grade them but to learn their students' background about the SSI topic in line with the purpose of diagnostic assessment. .

> "Then teacher will learn what they know about the topic and the prior topic. Teacher evaluates them with Kahoot platform. Teacher adds the music back to motivate them." (SI_G4_FO, ILP)

> "For diagnostic assessment I will use Kahoot results. Students will not be graded on these results but with the help of it I will understand what students know about the issue before I taught." (SI_G7_IT, ILP)

> Diagnostic assessment provides information about each student's prior knowledge about the content. Therefore, a teacher can use these data's at the beginning of the lesson and differentiate his/her main points according to the missing parts of the students' knowledge. In that manner, we can consider the Kahoot program as a diagnostic assessment strategy because teacher uses the program in order to see the student's prior knowledge at the beginning of the class. (SI_G6_MCO, ILP)

This difference between the implementations about the technology integration into diagnostic assessment process may be caused from the changes in the implementation. Since the teaching assistant of the course used Kahoot program for diagnostic assessment in the sample teaching performance, the PSTs from the second implementation decided to use the same tool for the same purpose. This finding even supports our restated eighth design principle (DP8): PSTs should be provided role models of effective SSI teaching with technology, which shows similarity with them. Since they experienced as a student that participating the online quiz on Kahoot helped them to recall their background knowledge in an enjoyable manner, they decided to implement technology in a similar vein.

Some of the PSTs from the both implementations stated that they would use the data they gathered in diagnostic assessment. However, most of these PSTs did not explicate how these data would be used.

> “As a diagnostic assessment strategy, at the beginning of the lesson, I will ask them questions to understand what their prior conceptions are about the topic. Their answers to these questions will be used to determine the flow of the rest of the argumentation.” (FI_G3_GI, ILP)

Two of the PSTs mentioned what they would do with the data gathered in diagnostic assessment. One of them stated that the teacher would decide to give extra information according to the students’ answers. Other PST decided to use the results of the quiz as grouping criteria to form heterogeneous groups.

> “S/he will begin the lesson with a question to know students' knowledge about cloning. If there any lack of information, teacher will give some needed information to them and then, students will begin argumentation.” (FI_G4_EA, ILP)

> “Teacher control students’ background information and create heterogeneous home groups for example there would be one students having high, medium and low scores.” (SI_G1_AO, ILP)

Summative assessment plans of PST in different implementation showed similarity. They planned to use similar methods for summative purpose.

The most frequently used summative assessment method was quiz for both implementations (n_{FI}=8, n_{SI}=10). They planned to make quiz either at school or at home with the help of technology.

> “At the end of the lesson, I make quiz to see whether or not they understand. After they compete the quiz, I will give feedback to each student.” (FI_G2_MBT, ILP)

Three of the PSTs from the first implementation and three of the PSTs from the second implementation took advantage of technology for summative assessment. Two PSTs from the first implementation planned to use Edmodo for online quiz while one of them planned to deliver quiz questions via Dropbox. One PST from the second implementation planned to use Quia. Moreover, two PSTs stated that they would use online quiz without giving any details about the tool.

> “Teacher can assess the students’ understanding with technology. For example, students will solve the questions at home from the Quia and teacher can see the results so teacher also have an opportunity to evaluate their understanding.” (SI_G4_FO, ILP)

Some of the PSTs (n_{FI}=2, n_{SI}=9) preferred to use concept maps for summative assessment. By asking students to prepare concept maps with concept map preparation tools, they planned to figure out students' understanding about the topic.

> "Moreover, teacher wants students to prepare a concept map about gene cloning in order to get a clear picture of what was covered during lesson and draw connections between the various concepts they learn." (FI_G2_AK, ILP)

> "Thus, teacher asks students to draw a concept map showing all the proponent and opponent ideas and, the relationship between them in order to see how clear is the concepts in student's minds and if they are able to reflect what they have learnt in a schematic way." (SI_G6_MCO, ILP)

While seven PSTs (n_{FI}=5, n_{SI}=2) stated that they would ask from students to write reports, six PSTs (n_{FI}=3, n_{SI}=3) planned to want from students to write journals about the issue at the end of the lesson. Although they called it different, the content of these homework are same. In both of them, PSTs ask students to write essays about the issue.

> "After all as summative assessment, the teacher gives students an assignment about writing journal about today's topic." (FI_G1_AA, ILP)

For the report assignment, one of the PSTs stated that:

> "Now, I will give you an assignment for today's topic. You will write an essay about the advantages and disadvantages of hydroelectric power plant in terms of government, public, economists and environmentalists." (FI_G1_AG, ILP)

As another alternative for summative evaluation, some of the PSTs (n_{FI}=3, n_{SI}=7) planned to use reflection paper. Through these reflection papers, PSTs planned to ask students to reflect on their understanding of the topic.

> "The teacher wants from students to write a reflection paper about this lesson. She wants from them to write what was their idea about this topic at the beginning, during the research, what they learned and did their ideas change, how antibiotics work they did like the argumentation method and they want to add other things and they send via e-mail or Facebook to the teacher." (SI_G1_FS, ILP)

One of the PSTs stated that reflection paper could give opportunity for teacher to learn also withdrawn students' ideas. If there were some students hesitated to express his/her own ideas, they can easily express themselves in this reflection paper. Most of them also planned to want students to send the reflection paper via e-mail or other online communication platform like OneDrive or Facebook.

> "At the end of the discussion after the final decision about whether nuclear power plant is supplied or not, the teacher wants from students to write a homework about the ideas in their minds in terms of topic. Because if students have different ideas and not say in class discussion, the teacher will inform from homework papers.teacher observe how students defend their topic or not.ssome students may have different ideas to refute or create a new one.this is think that a reflection paper for this discussion lesson.also, teacher understand that how this lesson affect to students and how they learn effectively." (SI_G4_EY, ILP)

Nine PSTs (n_{FI}=5, n_{SI}=4) planned to ask students to prepare a booklet or poster as a group. With these prepared materials, PSTs aimed to reinforce their students to inform the society (the school as the representative of the society) about the issue and their decision on the issue at the end of the argumentation. PSTs also planned to encourage their students to use technology to prepare these materials.

> "For summative assessment, I will give students a homework asking them to prepare a poster about the topic together with their group mates. They will be assessed on these posters and if there is a problem, I am sure that students will warn me about their group mates. So it will ease the process for me to assess them." (SI_G7_IT, ILP)

> "Now let's try to raise awareness and prepare a booklet for our friends and families. Please open the blog and click the booklet link on the right side and use online PowerPoint application to prepare your booklet." (FI_G7_BB, ILP)

This kind of assignment can be a good idea for different reasons. As Simmon and Zeidler (2003) suggested engaging students to activities, and helping them to understand the resemblance of the activities conducted in the classroom to real scientific community. By preparing an informative material to their friends and families, students' may feel themselves about the decision maker in the society. Therefore, it helps them to develop an understanding on nature of science.

Although their numbers are less, three PSTs (n_{FI}=1, n_{SI}=2) planned to use self-assessment and two PSTs (n_{FI}=1, n_{SI}=1) planned to use peer-assessment for summative assessment.

> "The teacher gives students evaluation form as homework so s/he can compare the results s/he did and students filled." (SI_G1_CU, ILP)
>
> "They will fill the group evaluation form to assess themselves." (SI_G1_FS, ILP)

To conclude, except using exams, PSTs from the both implementations used similar summative assessment methods. Moreover, there were not obvious discrepancies in PSTs summative evaluation plans between group lesson plans and individual lesson plans. Except exams, peer-assessment and self-assessment methods, all of the methods used for summative purposes were same. About technology use for the purpose of assessment, although PSTs planned to make use of different technological tools for diagnostic assessment, they did not plan to use different technological tools for summative assessment.

As it was mentioned above, PSTs focused more on their formative assessment methods. Among different formative assessment strategies, observing by walking around the groups was most frequently stated method for collecting data about students' progress. Almost all of the PSTs (n_{FI}=35, n_{SI}=38) mentioned how and what they will observe to assess students' progress. Although PSTs mentioned that they would observe students during classroom activities, their focus on observation showed differences. Some of them stated that they would observe whether students are dealing with the task, while some of them observed the quality of their argumentation. That is, PSTs planned to learn what kind of evidences students are offering and whether they can rebut the counter arguments in a meaningful way.

As it can be inferred from the below quotations, some of the PSTs planned to get idea about students' progress by looking at groups' computer screen while walking around the classroom.

> "Teacher will walk around the classroom and check and monitor the students whether they are focused on the work or not. Moreover, teacher

> will help students, if they have any problems about using technology or content.” (FI_G1_AG, ILP)
>
> “In addition, while walking around classroom I will control laptops’ screen about whether students enter different web-sites and social network or not.” (FI_G1_BK, ILP)
>
> “Teacher walks around the class and monitor the student action on computer. While walking around, she can easily detect the student’s difficulties about the using technology.” (FI_G5_AKA, ILP)

On the other hand, some of the PSTs mentioned more detailed observations about students’ progress. As it can be understood from the below quotations, they planned to understand their students’ argumentation skills.

> “During the discussions, I will assess their communication and argumentation skills as well by listening each idea and maybe I can ask some directive questions like ‘What do you think about the other effects of it, did you consider this, or what do they can say to refute their ideas, how can you defend yourself, etc.’” (SI_G5_NFO, ILP)
>
> “Also, I assess the students during the lesson. That is, I ask all students questions about the topic and pro and con-arguments. I measure the knowledge of students whether they are aware of the pro or con-arguments of all groups and what they are thinking about this issue. (SI_G2_DB, ILP)

PSTs planned to interfere with guiding questions according to their observations of students’ argumentation. They planned to help students find evidences to justify their claims or rebut the counter-arguments by asking guiding questions. Moreover, PSTs planned to trigger students to think critically about the reliability of their evidences.

> “Teacher observes students; if necessary she asks directed questions, she controls the group writings from the Google doc on smart board. According their performance on the Google doc, teacher guide them. For example, teacher asks to govern them “what do you try to say by writing this sentence? What do you think to convince others about the validity of your particular assertion etc.” (SI_G5_HY, ILP)
>
> “Teacher will check the groups during discussion and guide them by asking some question to groups like what are your arguments how you supported them. Also she will control the groups if they far away from issue or not.” (SI_G1_EC, ILP)

Although PSTs from both implementations planned to use similar methods for formative assessment, PSTs from the first implementation focused more on whether the students are on task by observing their participation to the group work and observing their computer screens whether they are searching the topic or not. On the other hand, PSTs from the second implementation focused more on the quality of argumentation while observing groups' activities. They generally planned to accomplish this by asking questions to the groups. Although PSTs from the first implementation also stated that they will ask questions to the students to understand their progress they did not mention the content of these questions. They generally included such general covert statements about the planned questions as given below.

> "For the formative assessment teacher always asks questions to the student." (FI_G1_MK, ILP)

> "Teacher will monitor students by walking around class. S/he will ask questions about their improvement. If they have problems, s/he will intervene in the problems at once." (FI_G1_SKO, ILP)

> "I will use formative assessment by asking some questions during the discussion and preparation part of the discussion." (FI_G8_CAY, ILP)

Thirty five PSTs (n_{FI}=18, n_{SI}=17) stated that they would ask questions while observing to assess students' progress. Among these, only two of the PSTs from the first implementation mentioned about the details of the questions that they would question the reliability of students' resources that they can reach through technology while walking around the groups.

> "Teacher observes the technology usage of students and their interest on it. Asks them to how can take information so according to which criteria then decide to it is reliable or not." (FI_G3_MSY, ILP)

On the other hand, 10 out of 17 PST from the second implementation mentioned that they would ask questions to the students about how to construct their claim, how to find evidences or how to critique the reliability of the evidences they found or other groups offered to them.

> "During the argumentation, to participate students in discussion, teacher asks questions like that what you think about this. What can be the

> reason for this? What are the other groups' evidences?" (SI_G2_DB, ILP)

> "In addition to this, teacher can ask them to how can take information so according to which criteria then decide to whether their evidence reliable or not." (SI_G1_DC, ILP)

> "Teacher observes students behaviors during the discussion part and directs each group members for example "you are a scientist, you must think yourself like a scientist. How do you justify their claims using appropriate evidence about nuclear power plants? How do you persuade others about the validity of those claims? How do you develop your ideas?" thanks to these questions, students can construct scientific explanations deeply and express their ideas clearly and teacher can assess her own teaching according to their answers." (SI_G5_HY, ILP)

From these quotations, it can be argued that PSTs in the second implementation were more knowledgeable about what to consider while assessing the argumentation of their students. This can also be verified with the finding that more PSTs from the second implementation used rubric to guide their observations. Twenty PSTs (n_{FI}=3, n_{SI}=17) decided to use rubric to assess their students during the activities. Among the three PSTs from the first implementation mentioning their plan about rubric use, one of them did not provide the items of the rubric. The other two PSTs provided already existing rubrics they found in the literature to assess students in cooperative learning activity. On the other hand, PSTs in the second implementation provided the items of the planned rubric. While some of them only included items to assess cooperation skills of students, most of them included items to assess argumentation and technology usage skills as well. The below quotation include the rubric items of one of the most comprehensive rubric provided by a PST from the second implementation.

> "1) Being knowledgeable about the articles, 2) being able to work in harmony in the group, 3) To contribute the groups work by creating ideas, 4) Communication with other group members, 5) Sharing own idea with others, 6) Recognizing different ideas, 7) Respecting different ideas, 8) Collecting evidence, 9) Rearranging idea based on collected evidences or shared ideas, 10) To argue with others based on evidence, 11) Considering the ideas of opponents of own ideas, 12) Considering the evidences of opponents, 13) Collecting data to refute opponents, 14) Presenting of collected data for refutation, 15) Persuading of others, 16) Acting polite way, 17) Usage of technology (how many different tools), 18) Being knowledgeable about technological tools, 19) Considering society, 20) Integration of daily life." (SI_G1_CU, ILP)

Although some of the items of the rubric given in above quotation were not clear, it is a good example to reflect PSTs' consideration of different skills of students in assessment.

Some of the PSTs (n_{FI}=15, n_{SI}=21) planned to make more systematic observation by using technological tools. PSTs generally stated that besides walking around the classroom to observe group works, they would observe groups' idea sharing through the websites allowing co-construction on teacher's monitor. Since they may have difficulty in understanding whether groups are producing claims, or rebutting counter-arguments by walking around the classroom, PSTs planned to assess their progress also monitoring the groups from the online communication or cloud storage programs through which they planned to conduct discussions. While observing the written or shared ideas in these online communication platforms, if a need arise, PSTs planned to intervene the groups' work.

> "I will check their ideas about issue on googledoc with using my own computer. (Thus students can follow both from their own groups' computer and from board connected to projection machine) ıf there is a mistake or any misconception, I will go to the group and I will guide them with my thought provoking questions." (SI_G8_GGU, ILP)

> "I can monitor the students with the help of blog and Google Documents." (SI_G7_HK, ILP)

> "During discussion, teacher has to be active all the time and follow all of the students' progress. For this purpose, teacher can use google document page and check whether students are constructing their own claims, evidences, counter-arguments and rebuttals." (SI_G6_MCO, ILP)

By observing both the classroom environment and online discussions, PSTs planned to get a complete idea about students' progress. Therefore, the teacher can easily guide the students in their progress.

Moreover, one of the PSTs from the second implementation took advantage of a technological tool in a different way for formative assessment. She planned to use Classdojo which is a website designed to let teachers share regular, positive feedback in class and on students' portfolios.

> "She will assess their working with class dojo program and also she will walk around and have a facilitator role while students are discussing the issue. For example she might ask them driving questions about the issue." (SI_G5_NFO, ILP)

To sum up, the PSTs gave more elaborated information about their assessment plan with technology in individual lesson plans as compared to the group lesson plans in general. However, there were some differences in assessment plan between the PSTs from two different implementations as retrieved from the individual lesson plans. There are mainly two differences. Firstly, in terms of technology support in assessment, the PSTs from the second implementation made use of technology in a more varied and practical way. The PSTs from the second implementation planned to make assessment more enjoyable and collect data from each of the students by making online quizzes for diagnostic purposes. Moreover, since more PSTs from the second implementation used technologies allowing for co-writing (like OneDrive, Google Doc) for idea sharing, they planned to monitor students' progress easily through these tools.

The other main difference was found between PSTs of different implementation in terms of formative assessment. While PSTs from the first implementation planned to understand whether students are on task and participating the activities, PSTs from the second implementation focused on the communication within and among the groups and tried to understand students' argumentation skills through these communications.

As it can be seen from the strategies used for technology integration into argumentation, PSTs employed instructional tools and representation to meet their instructional goals. PSTs' technology integration strategies was found student-centered and based on the idea of allowing students to construct their own knowledge. They used technologies to transform their teaching into more inquiry-based, student-centered approach based on social constructivist learning.

There were some differences between groups' and individual PSTs' technology integration strategies as retrieved from the individual lesson plans and group lesson plans. Although groups planned to use technology for allowing search, visualizing, giving information, motivating, communication, classroom management and assessment from most frequently stated to the least frequently selected, the order of the frequencies for each category showed differences in the individual lesson plans. PSTs mostly used technology for giving information and communication. Then, they stated search, classroom management, visualization, motivation and assessment, respectively, as their rational for technology use. These differences indicated that PSTs' most important reason for technology use was facilitating their argumentation. Since by giving information and allowing communication, PSTs aimed to facilitate their implementation of argumentation. On the other hand, communication was among the least stated reason in the group lesson plans. This can be interpreted that PSTs started to implement technology into their instructional strategies effectively, which is the indication of increase in the effectiveness of SSI teaching with technology.

4.2.3. The increase in the quality of teaching SSI through argumentation

As the groups of both implementation stated in their lesson plans, most of the groups utilized argumentation in their teaching performances. However, the quality of the implementation of argumentation showed difference between the groups. For the first implementation, since they did not utilize argumentation, third and fourth groups' performances were not analyzed for the quality of the implementation of argumentation strategy. Among the other groups, the quality of the groups' implementation of argumentation increased in time. The quality of their teaching was evaluated by looking at their effectiveness in managing the argumentation processes (both written and oral argumentation) by providing necessary guidance and creating a proper environment to facilitate argumentation. For this reason Simon et al.'s (2006) codes and categories for argumentation processes were adapted. The strategies each group used to manage written and oral argumentation were checked on Table 17.

Table 17.
Strategies Used for Managing Written and Oral Argumentation Processes

Categories of argumentation processes	Strategies used for managing argumentation processes	First implementation groups						Second implementation groups							
		1	2	5	6	7	8	1	2	3	4	5	6	7	8
Strategies to manage written argumentation															
Constructing claim	Assigning roles	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Providing worksheet		✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓
	Providing WebQuest, blog or other web-based learning environment			✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Justifying with evidence	Allowing search	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Providing resources		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Warning for possible bias	✓			✓	✓		✓						✓	
Counter arguing/debating	Allowing collaborative writing with opposing group from one dimension				✓	✓	✓	✓	✓	✓		✓	✓	✓	
	Allowing collaborative writing with all groups from all dimensions					✓	✓						✓		
Strategies to manage oral argumentation															
Constructing arguments	Encouraging claim presentation	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓
Justifying with evidence	Checking evidence	✓		✓		✓	✓	✓	✓	✓		✓	✓	✓	✓
	Prompting justification				✓	✓	✓		✓	✓		✓	✓	✓	
Counter arguing	Summarizing groups' arguments					✓	✓			✓		✓	✓	✓	
	Encouraging anticipating arguments	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	
	Posing questions to related groups					✓	✓			✓		✓	✓	✓	

Although there were some common strategies used for argumentation processes by each group, the quality of argumentation processes increased in time. Generally, the later groups used various strategies increasing their effectiveness in implementing argumentation with technology. Different strategies were used to manage written and oral argumentation processes.

4.2.3.1. Written argumentation

All of the groups started with their SSI teaching with written argumentation in small groups and large groups. Then, they conducted large group or whole class discussions for oral argumentation. First, in order to manage written argumentation, all of the groups used assigning role to help students construct their claims. Most of the groups formed smalls groups based on students assigned roles. Alternatively, they formed small groups and assign roles to the groups. Therefore, each group was expected to write their claims congruent with their roles. That is, if they were proponent of HES construction, they were expected to write claim supporting the construction of HES. Moreover, if they were given the role of proponent economist, they were expected to write claim supporting the HES construction due to its economical profits.

Moreover, most of the groups distributed a worksheet to the small groups of students. These worksheets included what to consider in writing claims. Moreover, they were expected to write evidences and counter-arguments related to their claims. Beginning from the fifth group of the first implementation, PSTs designed web-based learning environment like blogs, webquest or learning management systems. PSTs embedded worksheets into these web-based learning environments.

In order to justify their claims with evidences all of the groups allowed students to do research. They provided laptops and tablets or let students to use their mobile phones to do research. In order to manage their research, except the first group of the first implementation, groups provided related information resources for students. About half of the groups (n_{FI}=3, n_{SI}=2) warned students about the possible biases of the information that they can reached through internet search. By this way, they aimed to develop their students' SSI reasoning skills. Therefore, students would be able to employ skepticism when presented potentially biased information. These groups also provided guidance about reaching reliable sources of information.

In order to facilitate counter arguing and debating, PSTs mainly utilized collaborative writing tools. They either provided the links about online word documents in worksheets or embedded the links into the web-based learning environment. Through writing their claims on the shared file, students were given opportunity to see counter-arguments. Therefore, they were able to find evidences to refute other groups' argument. While some of the PSTs allowed the communication between the groups with opposing claims from one dimension of the SSI, other PSTs allowed communication of all of the groups. Therefore, students had also opportunity to grasp the multi-perspective nature of the SSI and complexity of the SSI.

Although there were similarities, the effectiveness of the PSTs in managing the written argumentation processes increased from the first group to the last group. First, the selection of technology changed in time in a way that facilitates students' argumentation. In the first implementation, the first group presented the issue and provided computers to the groups of students to allow searching about the issue. To guide their research, they distributed worksheet including some questions to be answered in light of research. The second group followed a similar process. Differently, they distributed concept cartoons to inform students about the arguments to be guide for their research.

Fifth group was the first who utilized a technology that guide students in the argumentation process. They decided to use webquest and asked students to follow the steps written in the webquest. In the webquest, there were introduction, tasks, processes, evaluation and conclusion pages. In the tasks page, they introduced the task that students were expected to complete. The following quote copied from their webquest.

> "Here we are. Your mission starts.
> There are many controversies about human cloning in today's era.It cannot be answered by only one group of people (e.g. ethicists or scientists). That is why you will work in groups of three to carry out the tasks to complete this webquest. Each of you will take a role to explore the subject in detail from the perspective of the role you have taken.

> Each individual is responsible for his own research, examining, and understanding the issue and required to share it with your group-mates. Do not forget: Each individual's contribution is vital to complete the task! As a group, you will write a report to share your perspective on the issue which will be published in our website and make a power point presentation of your report in class." (Retrieved from the Webquest which is designed by Group 5 of first implementation, Source: http://zunal.com/tasks.php?w=267173)

In the processes page, this group provided detailed information about how students were expected to form group, what each group was expected to do, which questions each group should consider in their research etc. The PSTs in the fifth group decided to assign roles to the groups of students representing different stakeholders related to the issue. They asked students to act like scientists, ethicists and legislators. Then, they explained the processes to be followed by each group in detail. Moreover, they included the questions that should guide students' research and provided some useful links to visit to collect information. The explanation in the Webquest for the responsibilities of one group of students was provided in the below quotation.

> "As a legislator, you are responsible for exploring the policies, laws and regulations regarding human cloning. You need to examine, analyze and evaluate your findings to generate your argument and to position yourself in the debate. Try to answer the following questions while carrying out your task: 1) What are the current policies, laws and regulations regarding human cloning?, 2) Should human cloning be banned or allowed? What should be the role of the governments?, 3) Is there a potential need to control and direct research and experiment on cloning? Who should hold this power? Why?
> The following links might be useful for you." (Retrieved from the Webquest which is designed by Group 5 of first implementation, Source: http://zunal.com/process.php?w=267173)

It can be clearly seen from the retrieved segments of the webquest that the group used very detailed guidance to the students that is helpful in facilitating their argumentation. By assigning roles to the students and providing detailed guidance in the webquest, the group helped students to consider different aspects in the issue. Therefore, they contributed to their students' understanding of the multifaceted nature of SSI.

After the students searched for the evidences from the resources teacher provided, the groups with opposing ideas with the same role were asked to come together and discuss their arguments orally. Although the fifth group was effective in facilitating students to think about different aspects through technology, they did not use any technology to facilitate students in considering counter-arguments. Sixth group used OneDrive for this purpose, although they did not mention in their lesson plan. They also grouped students based on different roles. They provided case to be investigated and asked groups with opposing ideas to share their claims and evidences with each other through collaborative writing tool, OneDrive.

The seventh group also used OneDrive file and designed a blog to help students follow the steps in the lesson. This group was very effective in monitoring the students' progress in argumentation through OneDrive. For example, the group members of the seventh group controlled each group of students during their claim construction by looking at their claims written on OneDrive. One of the PSTs in this group continuously looked at the teacher computer to understand whether the groups were able to construct claims. When the PST observed a group with irrelevant or problematic claims, she asked the groups whether they need help or not.

> "FB: I see that your claim needs to be revised. Do you need help for correction?" (Teaching performance of Group 7 in first implementation, Time: 36:00)

Similarly, the eighth groups in the first implementation used Facebook for sharing resources to help students search for finding evidences. Moreover, PSTs asked the students to share their claims with those who have opposite idea by forming groups for each aspect. They also observed the students' progress in argumentation by looking at their writings in the discussions conducted in the Facebook groups.

4.2.3.2. Oral argumentation

Besides facilitating written argumentation with technological tools, the groups also used different strategies to facilitate oral argumentation processes. The effectiveness of the groups in managing the argumentation also increased in time. Firstly, the groups’ effectiveness in fostering the students for providing evidence improved over time. Although the first group asked for evidences for students’ claims in the whole class discussion frequently, they did not foster the students to find evidences in their search as it was given in the following quotation from the teaching performances.

> “*The teacher who manages the whole class discussion looked at the blackboard for the claims written by groups.*
> Teacher: …, what was your evidence here?
> Student: What is my evidence…?
> Teacher: Yes, you need to prove it with evidence.
> ..
> Student: Today, there is not much active volcano. I think, it was quite much in the third geological time. Why there was not global warming at that time and there is today?
> Teacher: Are you sure, there was not?
> Student: I am not sure but…
> Teacher: You need evidences for showing this.” (Teaching performance of Group 1 in first implementation, Time: 57:48, 1:03:45)

Similarly, the sixth group in the first implementation also fostered students in providing evidence for their claims without facilitating them to find evidence while they are searching. As it was stated previously, the fifth group designed a very effective WebQuest to help students for finding evidences; however, they were not effective in managing the whole class discussion in terms of querying students' evidences for their claims.

On the other hand, the seventh and eighth groups in the first implementation facilitated students effectively to justify their claims and provide evidences for their claims during both searching and making discussion as a class.

> “*While the groups are searching, the teacher made a warning to whole class.*
> Teacher: Please support your claims with evidences. You have some trusted links there and you can use them for finding evidences to your claims.
> …
> *Teacher asks the groups to explain their claims to the whole class.*
> Teacher: Why do you think that vaccination should be used?
> Student: It protects us from diseases.
> Teacher: Yes. What is your evidence for this claim?” (Teaching performance of Group 7 in first implementation, Time: 34:20, 41:32)

In whole class argumentation, again, the sixth, seventh and eighth group were the most effective groups in managing the flow of discussion. That is, when the groups mentioned their claims and evidences, the teachers asked the group with opposing ideas to refute their evidences. Therefore, they were quite effective in pursuing the groups' ideas, helping them to think the counter-arguments to an argument, and to foster rebutting of the students. Group 1 also tried to direct students for mentioning the counter-arguments to an argument, but they were not much effective about deciding which group can do this. The last three groups were effective in directing questions to the related students by considering their area of search.

Lastly, about pursuing the students' ideas throughout the discussions, the last group of the first implementation was the most effective. They always summarized groups' claims to the other groups and effectively directed discussion to the related groups for providing their evidences. They had control on each groups' ideas; therefore, they managed the discussion fluently. Similarly, the seventh group was also more effective in this regard than the other previous groups.

> "*The teacher asked one groups to explain their claims to their friends. Then she summarized it to the class.*
> Teacher: Friends. Group E said that because of vaccination there would be some misusing problems. As a result, they think that vaccination is not required.
> *After the group's explanation, the teacher gave right to speak to the group with opposing idea. After the group explained their idea, the teacher again summarized it to the class.*
> Teacher: Group B said for this argument that yes may be there are some misused occasions, but it is important that the benefits are more important and wider that the risk of misusing." (Teaching performance of Group 7 in first implementation, Time: 44:24, 45:16)

Overall, it can be said that although the theoretical knowledge of the groups about argumentation as retrieved from the group lesson plans did not show much clear differences between the groups, the practical knowledge of the groups increased throughout the course in the first implementation.

However, the increase in the quality of implementation of argumentation was not salient in the second implementation. All of the groups implemented the argumentation strategy effectively with differing qualities in different parts of argumentation. First of all, the groups in the second implementation were more successful in facilitating the written argumentation by using different online communication tools and collaborative writing tools. All of the groups used an online communication platform (BeyazPano and blog) as they wrote in their lesson plans. They gave resources to each group in these platforms. Moreover, they included the links of the collaborative writing files in these platforms. Although some of them did not mention in their group lesson plans, all of the groups used a collaborative writing tool (OneDrive and GoogleDrive). The groups' facilitation of argumentation through technology showed similarity. All of the groups gave roles to the students representing different aspects of the issue. Then, all of the groups provided different types of resources (reports, regulation files, articles, website links, videos, graphics etc.) related to the each aspect through either Beyaz Pano or the blog they designed for this lesson.

Although the designs of some of the blogs were more user-friendly, all of the tools were quite functional in guiding the argumentation process. The last group used only blog to guide students in searching. They did not prefer to use collaborative writing tools, because they used jigsaw method. Although there was also another group in the first implementation stating in their lesson plan that they will use jigsaw in teaching, this group was the only one implementing the jigsaw strategy. They formed six groups including proponents and opponents of three different aspects of the SSI. After these six groups produced a claim by searching, another grouping was done. The second groups included one representative from each original group. Therefore, they did not feel need for using a collaborative writing tool, because each group was informed about the arguments of the other groups in the second step of the jigsaw.

The quality differences for the teachings of the groups in the second implementation were observed in the facilitation of oral argumentation and presenting the arguments to the classroom before starting to the argumentation activities. Since the groups in the second implementation were devoted an additional half hour to present the issue to the class, they designed different activities to present their issue. First group preferred to use two videos and one simulation to explain the working principle of hydroelectric power plant and to present the views of different stakeholders (public, hydroelectric power plant construction company and environmentalists). Moreover, they used Prezi to organize their presentation. With these technologies, they tried to motivate students, to introduce the working principles of HES and some concepts related to HES, and to present multiple perspectives related to the issue.

The second group in the second implementation explained the scientific knowledge related to vaccination through Prezi. They explained blood cells, microorganisms, diseases caused from microorganisms and the defense mechanism of the human body via questioning and direct instruction. After a short online quiz to understand students' prior knowledge about vaccination, they conducted a Skype connection with a doctor to learn more about vaccination and the issues related to vaccination. Therefore, they used Skype to both introduce the scientific concepts and present the multiple perspectives about vaccination. Then, they summarized the arguments by writing on the whiteboard.

The third group of the second implementation used a poster, a video and two Prezi presentations. One of the presentations included the scientific background related to their SSI topic, genetically modified organisms. While they were presenting the scientific knowledge related to the issue, they also mentioned briefly about the history of producing the genetically modified organisms. The other presentation was used to present the different perspectives about the SSI. After presenting the different aspects of the issue, they did not made a summary, instead, mention about what they will do in the next week. Although the content of the presentations were quite informative, they had troubles in opening the files at the same time. They did not present in one file, instead prepared two different files.

The fourth group was the least successful group in presenting the issue to the class. They started with an online quiz to see what students know about the issue. Then they explained the scientific concepts related to gene therapy by writing on board. The group used Prezi presentation for presenting the different aspects of the SSI. However, they could not use the Prezi effectively. The presenter did not know how to use it so did not use the arrows to change the slides. Neither did she has expertise in arguments related to the SSI. Therefore, they were not able to respond to the students' questions related to the arguments.

Group 5 used variety of tools (PowerPoint presentations, graphics and Powtoon video) to present their SSI topic. Differently from the previous groups, this group asked students to find the pro and con arguments by giving data and graphics. Moreover, this group was the first to prepare a video to explain the arguments. By using Powtoon, they prepared an attractive video presenting proponent and opponent ideas related to their SSI topic, using chemical fertilization and pesticides in farming. They showed their awareness of the arguments while writing the summary of them on the board. They effectively summarized and were able to respond to different student questions regarding the arguments.

The sixth group was the most effective group in presenting their SSI topic, construction of road in Black Sea region. They did not utilize different tools (only one PowerPoint and one video), but the fluency of their presentation made the arguments understandable and followable. They explained an argument and then gave the counter-argument to that argument, and did this for each aspects. They used only one presentation file; therefore, there was a unity in their presentation indicating that all group members were accountable from the whole presentation. This was, indeed, observed in group members' answers to the questions. Moreover, they effectively made summary of the arguments related to the SSI topic. The fluency of their presentation reflected to the argumentation of the second week.

Similarly, the seventh group also presented their SSI topic, animal testing, effectively, with a single united PowerPoint for the delivery of scientific information and arguments. Moreover, they explained the history of animal testing in their presentation. Besides, they used an animation video to attract students. Then, in order to present the arguments from each aspect, they prepared a video including the interviews they conducted with the experts, scientists, pharmacists, and rule makers, related to the different aspects. Since their presentation showed unity, all of the group members were quite knowledgeable about their SSI topic and the arguments related to it. The last group also did the same thing with the seventh group. They presented their topic, human cloning, with PowerPoint presentation. Moreover, they prepared a video including a TV show explaining the arguments from different perspective. They acted like the experts participating in a TV show and explained their arguments in an enjoyable way.

As it was stated before, the quality of their management of oral discussion showed differences. The groups' performances were generally better than the groups of the first implementation. They used different methods for facilitating students in argumentation and fostering them to reach a common decision related to the issue. Two of the groups performed a panel at the end of the lesson for reaching a common decision as a class. Moreover, two of the groups assigned a teacher for each pair of group with opposite ideas in one aspect. At the end of the lesson, while discussing the arguments related to each aspect, those teachers summarized students' ideas to the class instead of asking for a representative from each group.

The fourth group was the least effective group in oral argumentation. Since they were not knowledgeable about the arguments related to their issue, they had difficulty in pursuing the students' ideas. They did not ask students to present their claims, provide counter-argument for claims and did not facilitate them to do rebuttal. What they did was only asking each group to explain their arguments to the class and telling them to decide whether the gene therapy should be used or not.

The rest of the groups showed a good performance in managing oral argumentation. Overall, the first and eighth groups' performances were relatively lower and the sixth and fifth groups' performances, who used panel at the end of the lesson, were relatively better as compared to the other groups. However, all of the groups, except the fourth group, were effective in varying degrees in facilitating their students to find and provide evidences to their claims, to consider and provide counter-argument, to rebut the counter-arguments, to consider the evidences from different aspects for an argument and to reach a common decision.

All of the groups except the first and fourth groups were effective in pursuing students' ideas. They effectively listened, understood the groups' claims, and guided the discussion fluently. This was the most salient in the groups who performed panel. A script retrieved from the panel organized by the fifth group can be given as an example.

> "*After the representative of the farmers explained their arguments in the given two minutes, the teacher summarized it.*
> Teacher: Then you said that chemicals are getting harmful for soil. If we use them by controlling, for example, analyzing the soil's need. Am I right? Then we can use it. May be you (*turned to the scientist*) can say something about this issue. Is it possible?" (Teaching performance of Group 5 in second implementation, Time: 41:04)

The seventh group summarized also the changes in the groups' ideas after listening the other groups' claims and evidences.

> "Teacher: Do you think your idea changed or not? Still think the same?
> Student from consumer group: We are conditionally agree after listening them.
> Teacher: I think they (*consumer group*) just recognized that one medicine enters the body and goes through the steps in the organism. So just an artificial issue cannot be able to support this process and show the exact results. So, they decided to conditionally agree that animal can be tested for medicine." (Teaching performance of Group 7 in second implementation, Time: 41:44)

While asking students to explain their claims most of the groups were effectively facilitated students to provide evidences. For example, since the sixth group was quite knowledgeable about all of the arguments related to their issue, they did not have difficulty in helping student to find evidences in their search.

> "*Teacher helped one of the groups who had difficulty in finding evidence to refute the argument of the opponents of road construction.*
> Teacher: For example, we can think about applied high technology road examples from different countries. There are some roads designed to overcome these obstacles. Of course, they would be costly, but you can search about the applicability looking at the examples from other countries. (Teaching performance of Group 6 in second implementation, Time: 31:45)

On the other hand, the last group was not effective in fostering students to find and provide evidences for their claim. Instead, the teachers provided the evidences themselves. While observing the group discussion although the observer teachers faced with illogical arguments, they could not lead students to provide scientific evidences to those arguments. Moreover, the teachers were unable to resolve the conflicts of the students about scientific background of the issue. This two opposite example implementation of argumentation in terms of facilitating group discussion performed by the sixth and eighth groups indicated that the teachers were more effective in guiding student in their research if they know all of the arguments about their issue.

Some of the groups were also effective in facilitating students to think about an argument from multiple perspectives and rebut the claims from their own perspective. In their panel, the fifth group performed this successfully as it can be seen in below quotation.

> "Representative of scientists: As scientists, if we consider good and bad sides of the issue. From the good side we can grow crops easily in a short time and by this way farmers can get more money and supply the public's food needs. However, it has long-term bad effects in terms of soil. We can find out that there is an alternative to chemical fertilizers. There are also organic fertilizers. However, studies show that because farmers' education level are so low, especially in Turkey, farmers do not know about organic fertilizers. So we decided that controlled amount of organic fertilizers is better than using chemical fertilizers. Therefore, we provide an alternative opinion.
> Teachers: You said that we should use organic fertilizers, right. However, most farmers continue using chemical fertilizers. What do you think about this issue? What can we do in this situation? Can the new organic fertilizers' cost be near to chemical fertilizers." (Teaching performance of Group 5 in second implementation, Time: 41:39)

All of the groups tried to facilitate students to reach a class decision. Since the first and fourth groups were not much effective in managing the argumentation, they had difficulty in facilitating students to reach a decision. In the fourth groups' teaching performance, there was one group of students who agreed and two groups of students who disagreed with application of gene therapy. By urging the agreed group to become disagree without providing evidences to rebut their claims, the teachers made the class to reach an agreement.

Similarly, the eighth group directed argumentation in one way to reach the teacher's desired conclusion. In the eighth group, students were not allowed to express their ideas. Instead, the observer teachers of the groups summarized students' ideas. Then, all of the teachers stated that the group decided not to allow cloning by explaining the groups' findings. Therefore, the students did not stay in dilemma and be forced to make a decision by rebutting each other's ideas.

Although they effectively managed the argumentation with a panel, sixth group also directed the discussion in one way, intentionally. The teacher who managed the panel discussion frequently provided evidences to help support the groups who disagreed with road construction. On the other hand, they did not provide any evidence for the proponents of road construction.

> "*One of the representatives of the proponent groups tried to refute the opponents' idea that constructing some facilities like hospitals to the area may decrease the need for road construction.*
> Proponent panelist: Constructing hospital İS not enough. There may be some medicine or machine needs. How can these kinds of needs be supplied. To supply them, again some trucks or people should come from the city of the center. So the road again is needed.
> Teacher: There is already a road. If they want to carry, they can use this road. I think they can solve the problem in that way. Therefore, there is not a need for a new road. Therefore, we are deciding that we don't want a road for transportation. Am I right?
> *The class was laughing.*" (Teaching performance of Group 6 in second implementation, Time: 45:30)

Actually, the members of the sixth groups also stated in their VSRI that they directed the argumentation by prompting them with some evidences from the opponents as it can be understood from the below quotation. They stated that they did not want to be stucked while facilitating the classroom in reaching a class decision.

> "SI_G6_DC: For example, in here, Eda again entered to the discussion. I did not understand what her aim was. I became bewildered. Because the transportation part was over. In here, I wanted them to reach a decision whether the road should be constructed or not. Actually, I desired them to say that the road should not be constructed. Because I was more prepared for that decision. Therefore, I manipulate her answer a bit." (SI_VSRI_G6)

Overall, about practical knowledge of argumentation, the groups in the second implementation were better than the groups in the first implementation. They were mostly more effective in managing the argumentation to make the discussion fluent. They tried to increase the argumentation skills of their students by continuously asking them to provide evidence, consider the claims from different perspective, and try to refute them with further evidences. While doing this they were effective in pursuing the ideas of the students.

There were also effective groups in the first implementation. Generally, the quality of the implementation of argumentation increased from the first group to the last group in the first implementation. However, this pattern was not salient in the second implementation. Although the groups toward the end of the semester were more effective, there was not a straight increase in the quality from the beginning to the end of the semester. Moreover, the groups in the second implementation were more effective in taking advantage of technology in implementing the argumentation. Although the groups in the first implementation also used helpful technologies, the groups in the second implementation used technology in a more creative and functional way.

4.3. Nature of Science Issues

Considering SSI reasoning without NOS views of students may be a fallacious approach. There is a two-way relationship between SSI reasoning and NOS understanding. First, teaching science in the context of SSI contributes to the development of students' NOS understanding. On the other hand, their SSI reasoning is considerably affected from their views of NOS. Therefore, teachers should both aim to develop their students' NOS understanding and be aware of their epistemological orientations regarding the nature of science. For this reason, we analyzed group and individual lesson plans to examine whether PSTs aimed to develop students' NOS understanding. Moreover, in their reflection papers and interviews, we asked PSTs how much they were aware of their students' NOS views and the effect of those views on their decision-making. Therefore, in the following sections, PSTs' SSI teaching in term of development of NOS understanding and their awareness about the effect of NOS understanding of students on their SSI teaching were explained.

4.3.1. Developing NOS understanding

To understand PSTs' aims for developing NOS understanding, the objectives they wrote in their group and individual lesson plans were analyzed. In their lesson plan, PSTs were expected to write objectives from four learning areas of the Turkish science curriculum. They included their NOS objectives under knowledge, skills and STSE learning area. They mainly wrote objectives related to subjectivity aspect of NOS. However, few PSTs also included objectives related to tentative, creative, empirical-based and socio-cultural nature of nature of science.

However, although PSTs labelled as NOS objectives, some of the objectives indicated their misunderstanding of NOS. Those objectives indicating misunderstanding of NOS were coded by adding ‘misundestanding’. The number of groups and PSTs writing NOS objectives were given in Table 18. As it can be seen, PSTs wrote objectives about six aspects of NOS in total. However, the percentages of groups and individual PSTs writing NOS objectives were quite low.

Table 18.
Occurances of NOS Objectives in Group and Individual Lesson Plans

NOS aspects	Codes	GLP		ILP	
		FI	SI	FI	SI
Subjective nature of science	Subjective	2	3	6	7
	Misunderstanding	2	-	8	2
Tentative nature of science	Tentative	1	2	-	2
	Misunderstanding	-	-	2	-
Creative nature of science	Misunderstanding	1	-	4	-
Sociocultural nature of science	Sociocultural	-	1	-	1
Empirical nature of science	Empirical	-	-	-	2

The most frequently written NOS objectives was about subjective nature of science. The numbers of groups and PSTs writing objectives about subjective NOS aspect were similar in both implementation. Groups and individual PSTs generally included their objectives about subjective NOS aspect under skill learning area. One typical example to subjective NOS objectives can be given as below:

> “Explain the subjectivity that is one of the Nature of Science aspects (subjectivity-NOS).” (FI_G1_BK, ILP)

Five (n_{FI}=2, n_{SI}=3) out of 16 groups and 13 (n_{FI}=6, n_{SI}=7) out of 77 PSTs aimed to develop an understanding about the subjective nature of science. On the other hand, two groups' (FI) and 10 PST' (n_{FI}=8, n_{SI}=2) objectives indicated misunderstanding of this aspect. Therefore, although they labelled their objectives as subjective NOS objectives, their objectives did not indicate the clear purpose of developing understanding about subjective NOS. A typical subjective NOS objective indicating misunderstanding was given below.

> "8.5.4.6. Evaluate the positive results of the developments of genetic engineering. (NOS: Subjectivity)" (FI_G2, GLP)

The next frequently written NOS objectives was about tentative nature of science. Among them, only 2 PSTs from the first implementation misunderstood this aspect and wrote the below objectives.

> "Discuss GMO connected to genetic engineering.(NOS-tentativeness, SPS-Communication)" (FI_G7_OK, ILP)
>
> "Discuss animal experimentation which is connected to genetic engineering.(NOS-Tentativeness, SPS-Communicating)" (FI_G7_BB, ILP)

These two PSTs were from the same group, which is the seventh group of the first implementation. Actually, this group was among the most effective groups emphasizing the tentative nature of science. This groups' objective was:

> "6. Discuss the history of vaccination to understand the tentative nature of science. (NOS-Tentativeness)" (FI_G7, GLP)

Moreover, this group also stated when to emphasize NOS in their lesson plan. They planned to show a video about historical developments of vaccination. They aimed to show student the knowledge changes in time with further scientific experiements and evidences. They planned to emphasize NOS after the class reached a decision at the end of argumentation as in the following quotation.

> "You have discussed about your findings with other groups. And now, do you wonder about first vaccination in the world? Let's watch a video about the history of vaccination. (Obj.8) (Obj.10) As you see, science process takes time and not straight forward. Science is tentative and subject to change. (Obj.6)" (FI_G7, GLP)

Another typical tentative NOS objective written by other groups and PSTs was given below.

> “(OBJ 3) Identify the scientific knowledge as changeable information on the basis of experiments. (NOS: Tentativeness)” (SI_G7, GLP)

One group and four PSTs from the first implementation also mentioned about creative NOS in their lesson plans. However, all of these objectives indicated misunderstanding of creative NOS and as in the following quotation.

> “6.1.4.10. Preparing a concept map related to the vaccine. (NOS: Creativity)” (FI_G1_SK, ILP)

These PSTs confused creative nature of science with the creativity of students. It can be inferred from their objectives that is students create a product by using their creativity, they can develop understanding about creative nature of science.

About socially and culturally embeddedness of NOS, only one group and one PST from the second implementation wrote objectives as in the following quotation. Although most of the groups’ activities used in their SSI teaching performance were so suitable to develop understanding about this aspect of NOS, other groups and PSTs did not write objectives about sociocultural nature of science.

> “State that science is influenced by its society and its need (NOS-socially and culturally embedness)” (SI_G2, GLP)

Lastly, from the second implementation, 2 PSTs wrote objective for empirical NOS. The sample quotation was given below.

> “OBJ2- Express that the scientific information is emprically based. (NOS)” (SI_G7_MK, ILP)

Although the number of groups and PSTs writing NOS objectives were low in both implementation, the number of objectives indicating misunderstanding was lower in the second implementation as compared to the first implementation. None of the groups in the second implementation wrote NOS objectives indicating misunderstanding, while three groups from the first implementation wrote NOS objectives indicating misunderstanding. Similarly, number of PSTs writing NOS objectives indicating misunderstanding were lower in the second implementation (n_{SI}=2) as compared to the number of PSTs in the first implementation (n_{FI}=14).

There were differences between lesson plans and teaching performances in terms of explicit NOS emphasis. The first group of the first implementation wrote objectives about subjective NOS. However, they did not emphasize this NOS aspect explicitly in their teaching. This groups' SSI topic was about causes of global climate change. They formed groups supporting two opposite ideas; whether global climate change is a natural process or it is human-made. Therefore, they found evidence from two point of views. Therefore, their teaching performance provided students opportunity to understand the theory-laden/subjective nature of of science. Although they did not explicitly emphasized NOS in their teaching, they were able to determine to which NOS aspect their SSI topic contributed.

Similarly, the second group of the first implementation, the first group and the eighth group of the second implementation wrote objectives about subjective NOS. They did not emphasize NOS in their teaching explicitly either. Their SSI topics were whether using GMO should be allowed, whether HES should be constructed, and whether human cloning should be allowed, respectively. They assigned different roles to the groups and ask them to argue from different perspective. All groups found evidences supporting their point of view. Therefore, although they look at the same issue, they used different theoretical knowledge to explain their point of view. Therefore, their teaching was helpful in developing students' views about subjective NOS.

The first group of the second implementation wrote another NOS objective which was about tentative nature of science. However, they did not have any teaching and learning activity to help students understand this NOS aspect. The seventh groups of the first and second implementation were other two groups writing objective about tentative NOS. Both groups used video explaining this history of vaccination and animal testing. The video used by the seventh group of the first implementation included the changes in the scientific knowledge about vaccination in light of the experiments conducted throughout the history. The video used by the seventh group of the second implementation had also similar content explaining the changes in the views and knowledge about testing animals for experimentation. Therefore, these two groups reached their aim of developing tentative NOS understanding of their students through the videos about the history of their topic.

Although they did not write objective about developing tentative NOS understanding of their students, the fifth group of the second implementation also emphasized this NOS aspect in their teaching. They used similar strategy with the seventh groups. They utilized a video explaining the history of gene cloning. After the video, they summarized that scientific knowledge about genes and gene cloning has changed in time with the results of experiments. Moreover, they also emphasized that what we know currently about gene cloning may also changed some time in the future. Therefore, although they did not include objective about tentative NOS aspect in their lesson plan, this group also utilized technology to explicitly emphasis tentative nature of science.

The second group of the second implementation wrote objective about socially and culturally embeddedness of NOS. They both explicitly emphasized and included different strategies to develop students' understanding of this NOS aspect. This group addressed whether people should be vaccinated or not. In their initiation of teaching one of the group members pretended like a scientists and connected to the classroom via skype. She gave some basic scientific information about vaccines. Then, she mentioned about the debate in society about mandatory vaccination. She stated that in order to respond to the society's need, she, as a scientist, was conducting a research to figure out the risks and benefits of vaccination. She invited students to help her in her research about the vaccination as in the following quotation.

> "When I look at some cases at court there are some parent sued doctors about injecting vaccines mandatorily without consultation. I'm not sure if you heard about that in Turkey, Constitutional Court decided that there should be mandatory vaccines. Ministry of Health also declared that they should not need to ask us for this decision. I am doing a research about this issue. I found that many organizations are against mandatory vaccination and claimed that some of these vaccines have harmful ingredients and also some immoral ingredients and also they have side effects. People said that we should have natural immunity. Also these diseases targeted by vaccines are really rare now. I mean, they almost disappeared. So we do not need them. Next week I will come to your class and we will do more research about this topic together. We will decide and you will help me in my research. By this way, we would be

able to inform the society about this issue based on our research." (Teaching performance of Group 5 in second implementation, Time: 16:48-18:56)

With this talk of the scientist, they could effectively showed students how the concerns of the society affected scientific research and also how the results of scientific research affected the society. At the end of the teaching they also asked students to prepare a booklet to inform the society about their class decision. Therefore, this group included effective strategies to reach their aim of developing students' understanding about sociocultural nature of science.

Lastly, although they did not write objective related to sociocultural NOS, the fifth group of the second implementation also implemented similar activites to help students develop understanding of sociocultural NOS. Their topic was 'should chemical products (pecticides and chemical fertilizers) be used in croplands or not'. They asked students to pretend like farmers, scientists and consumers. Each group of students made research to find evidences to justify their claims based on their roles. Then, at the end of their teaching, they conducted a panel and invited the representors of each group. While grouping, they formed two farmer groups who supported and rejected chemical use, and two consumer groups who supported and rejected chemical use. However, they formed only one scientist group. Then, they asked scientist group to make research based on the farmers' and consumers' needs and concerns. Therefore, they emphasized the role of society on scientific research.

"Teacher (panel manager): You (farmer) said that chemicals are getting harmful for soil, but if we used them by controlling, for example by analyzing the soil's needs, we can use them. Am I right? May be you (scientist) can share your findings about this issue. (Teaching performance of Group 5 in second implementation, Time: 41:09-41:36)

Similarly, at the end of their teaching, this group emphasized that students acted like real society and reached a common decision about the issue. Then, they asked students to prepare a booklet to inform the society about their decision including the findings of the scientific experiments justifying their decision.

When we looked at other groups' teaching performances, although they did not have explicit NOS emphasis in their teaching, their teaching and learning activities are helpful developing an understanding about NOS, especially subjective and sociocultural NOS. They gave students an issue that they faced with in their daily life as society. Then, teachers asked students' to do research for finding scientific evidences about the issue from different perspective. Then, all of the groups asked students to reach a common informed decision as a class. By this way, they pretended like society. Therefore, they showed how society influence and be influenced from scientific developments. Moreover, all of the groups assigned roles to the students and asked them to search for evidences from their own point of view. Therefore, students were able to see the existence of competing theories about the same issue. By this way, they were able to understand theory-laden/ subjective nature of science.

To sum up, PSTs were not effective in deciding objectives to develop NOS understanding of students. However, they could effectively organize activities to help students develop understanding of NOS, especially sociocultural and subjective NOS. PSTs in the second implementation were better in determining the NOS objectives. Although groups' activities were generally effective for developing NOS understanding of students implicitly, few groups (n_{FI}=2, n_{SI}=2) made explicit NOS emphasis in their teaching.

4.3.2. Awareness about the role of students' epistemological beliefs on their SSI reasoning

PSTs who had concerns about the epistemological beliefs about the students planned to share reliable resources with them. They thought students in our culture are not skeptical about the possible biased information and tended to accept the knowledge they heard or read. Therefore, in order to prevent students from reaching unreliable and invalid knowledge resources, they decided to prepare a web-based learning environment which includes related reliable resources.

> "We are so traditional in that we are not much skeptical. While getting information about a topic, people in our society generally believe hearsay information. We do not generally search about it. Therefore, we integrated reliable and valid knowledge in the blog." (SI_G6_DT, PTSI)

There was a clear difference between two implementations in terms of giving instructions about the reliability of the sources. According to Sadler et al. (2007), being skeptical about the potentially biased information is one of the requirements of decision-making in SSI context. However, PSTs in second implementation did not emphasize it in their instructions. This may be caused from the differences of PSTs technology usage plan in different implementations. More PSTs in the second implementation decided to use online communication platforms as compared to the PSTs in the first implementation. The PSTs in second implementation who decided to use online communication platforms stated that they planned to use these tools to share resources. On the other hand, none of the PSTs from the first implementation stated sharing resources as one of their technology integration strategy to facilitate argumentation. Therefore, PSTs in the second implementation shared resources to the students to prevent their students from reaching unreliable or biased resources. On the other hand, since PSTs in the first implementation allowed their students to find resources themselves, they had concerns about the reliability of the resources as in the following quotations.

> "I will give instructions about reliable web sites extensions such as gov., edu., and some noncommercial organizations." (FI_G1_AG, ILP)

> "Teacher only makes a caution about the reliability of websites that students use them while making researches about the socio-scientific issue. So, teacher want to students that use only the websites that have the extension like gov, edu etc." (FI_G6_RO, ILP)

Four of the PSTs from the second implementation still needed to give instructions to their students about the reliability of the resources for in case of any further research.

> "In the blog, there are links to let them to make research about the phenomena. The students just need to open these links and read the information. If they need to search different information from given in the blog, then they need to know how they will reach reliable information on the internet. At this point, the teacher will remind them to use gov and edu web-sites." (SI_G1_CU, ILP)

Five groups from the second implementation (Table 16) used web-based learning environment for this purpose. They preferred to do research about the reliable and valid resources by themselves instead of expecting from their students to do search. However, although they provided related resources to the students, the PSTs also expected their students to develop necessary reasoning skills to analyze the information resource and decide its appropriateness. Therefore, they criticized students' reliance on the resources provided in blog.

> "I think students' epistemological beliefs are not sophisticated. I designed a blog and provided resources in the blog and encouraged them to discuss. Most of them relied only to the resource given in the blog. they did not criticize whether the resrouces I gave them were scientifically true. This may be related to their trust in me. They assumed that if I gave them these resources, they cannot be wrong." (SI_G6_HK, PTSI)

Similarly, other PSTs criticized their students in trusting internet resources without skepticism. They stated that students did google search to find evidences and did not think critically about the reliability of the resources.

> "Students think that what we found on the internet is true. May be we were also thinking like that until this course. student are assuming everthing they read on the internet is safe and reliable. If our friends were acting like this, the students in the elementary level would be even worse." (SI_G1_CU, PTSI)

PSTs stated that what they read on the resources, really affect students' standpoint. They observed that students' views about the topic was considerably affected from what they read.

> "They were determining their stand according to the content of the article. For example the articles second group read were mainly focused on the positive side of cloning. Therefore, they focused on also positive side as a group." (SI_G3_BB, PTSI)

Contrary to those PSTs criticizing their students for not being able to skeptical about the sources of the information, some of the PSTs stated that few students questioned the certainty of the knowledge. Since these students believe that scientific knowledge is open to change, evidences should be as current as possible. Therefore, they looked at the data critically and questioned its currency. This leaded students to search for further evidences.

> "Other group provided an evidence. This group wanted to look at the time of the article. This findings are open to change. although it was found in the aricle as one in a million, it may be found as five in a million

> in the experiment conducted after one year. therefore, they asked whether those data are current." (SI_G3_BB, PTSI)

It can be summarized that most of the PSTs in the second implementation stated that students would probably have difficulty in eliminating biased resources from their internet search. Therefore, they thought that providing reliable resources would be necessary. Based on their observations about the epistemology of students in their teaching, PSTs decided to provide reliable sources ready to students (Table 16) in their individual lesson plans. Besides, they also decided to warn students about the possible biased information that can be reached through internet search.

Some of the PSTs stated that in addition to students' epistemological and NOS beliefs, their own beliefs about the SSI also affected their reasoning. PSTs observed that some of the students were deeply committed to their arguments. Therefore, they tended to distort their evidences to persuade other groups.

Moreover, students' commitment to their arguments also affected the classroom decision process. Since students did not want give up their claim, they did not consider the claims of other groups in reaching decision. However, they tried to negotiate.

> "In decision making they were not fully convinced. Because they did not want to give up their claims. If they were not agreed with other groups' claims, other groups' evidences did not affect their decision much. However, they tried to negotiate in a way." (SI_G1_AO, PTSI)

Considering the difficulties previous groups face in decision-making process, later groups tried to find more effective strategies to encourage students to reach class discussion. Therefore, they organized panels in which the teacher facilitate argumentation. By this way, teacher easily triggered students to consider other groups' evidences and provide further evidences.

4.4. Cultural Issues

As researchers pointed out SSI teaching must aim to develop students' ethical and moral reasoning (Zeidler et al., 2005). Therefore, being aware of students' moral developmental level and finding ways to contribute students' moral development is essential. For this reason, PSTs awareness about their target students' developmental level (cognitive and moral) was investigated. By doing this, their ability to determine effective SSI topics to develop their moral reasoning was figured out. Moreover, the way they addressed ethical issues in their SSI teaching was examined.

4.4.1. Awareness about students' moral development

Since students were expected to engage in informal and moral reasoning processes in learning SSI topics, their cognitive and moral developmental levels were important. Therefore, PSTs should also consider the developmental levels of students while planning to teach an SSI topic. However, although PSTs were aware of the possible misconceptions and expected prior knowledge of students, they were not so good at analyzing the target students' developmental level.

Only seven groups (n_{FI}=5, n_{SI}=2) in total mentioned their target students' cognitive developmental level. Among them, four of the groups mentioned students' developmental levels based on Piaget's Theory of cognitive development stages.

> "At this stage, abstract reasoning begins to be functional in the students. During the eighth grade, student's cognitive skills are experiencing qualitative changes as they become fully able to systematically, hypothetically, and deductively." (FI_G5, GLP)

Other three groups confused developmental level with either prior knowledge or prior experiences. Therefore, they decided the appropriateness of the SSI to the students by considering its relatedness to daily life or referring to the curriculum for prior knowledge.

> "We think that this topic is appropriate issue for students. Because each student is vaccinated so vaccination are which is a topic in daily life. Therefore, this topic is also appropriate their cognitive level." (FI_G7, GLP)

> "The issue is appropriate for students' cognitive level. Because they have learned what is energy and they also use energy in their daily life." (FI_G8, GLP)

About moral developmental level, only four of the groups (n_{FI}=3, n_{SI}=1) considered students moral developmental level. Among them, one of the groups confused moral development with interest to the topic. Others mentioned their students' awareness of their action on society and environment.

> "At this stage, students are learning to accept responsibility for own failures and mistakes. Even if they are not ready to be accountable for all their actions and misdeeds, they are beginning to see their own role in their mistakes and failures. A skill that can help them be more open to constructive criticism, notes and editing from their teacher. Because this is a socio-scientific issue, they can easily see their mistakes in daily life. For example, they may begin to be careful when they use water in bath. They may recognize that if people do not take measures, natural sources can run out and their future can be affected negatively because of this. They may try to find solutions for environmental problems." (FI_G3, GLP)

Overall, groups were not good at determining their students' developmental level in their group lesson plans. On the other hand, with the help of reflections and the teachings conducted by themselves and other groups in the course, PSTs gained more awareness about the importance of cognitive and moral developmental level of students' to attain an effective SSI reasoning. Therefore, they reflected this in their individual lesson plans as in the following quotation.

> "My issue is nuclear power plant construction and according to me, students' developmental stages are important. During the lesson, I try to give information about issue in terms of different field and it can activate their critical thinking skills. In addition, they try to make argumentation about nuclear power plant should be established or not. When making argumentation they receive help from their opinion, background, ethical values, studies, researchers, and then they will make a decision by giving importance for their social contract, individual rights and universal principles. All these make their moral and cognitive developments important for learning SSI." (SI_G3_AFE, ILP)

PSTs made research about the developmental level of their target students and stated whether their students' developmental levels are appropriate for learning the issue. They also mentioned how their lesson may contribute to the students' cognitive and moral development.

More than half of the PSTs (n=45) mentioned their students' characteristics in terms of cognitive developmental level. While doing this, they mostly referred to the stages of Piaget's cognitive development theory.

> "In terms of cognitive development, if we consider the Piaget's stages of the cognitive development, we can say that these students may be in the concrete operational stage or in formal operations stage. In concrete operational stage, they are able to solve problems logically, and in formal operation stage, they can think hypothetically, they can produce alternative ways to problems, and they can think more abstract. When we think of these stages' properties, it is appropriate that students in 7th grade can understand the steps and importance of the organ donation and transplantation and they can talk about controversial issues, like organ donation between each other in a classroom environment. So, I think that we can discuss the organ donation issue in different perspectives with my students." (SI_G8_GGU, ILP)

> "Teacher makes cloning topic concrete, but students' level of understanding is suitable for abstract concepts according to Piaget's operational stages." (FI_G1_SKO, ILP)

Some of the PSTs also mentioned the role of their activities and instructional strategy in contributing to students' cognitive development.

> "About our issue, students made an activity based on discussion. According to their claims, they tried to find some evidences that support their claim. This process, students actually tried to make researches scientifically as scientists. It has a positive effect on students' development cognitively because this way, they know what they do in order to reach any information or data. By using online sources, they find evidences and they made a decision with their group members in order to reach a decision. It contributes to improve the ability of decision making of students." (SI_G6_MKA, ILP)

On the other hand, PSTs were not good at dealing with moral development of their students. Twenty-five PSTs wrote something about moral development of students. Some of the PSTs stated that students' moral developmental level is appropriate for being engaged in the activities of the lesson without mentioning any rationale for its appropriateness. Although they did not mention any theoretical background, some of the PSTs gave clear description of their students' moral developmental level. Almost all of the PSTs, who explained the students' moral development, mentioned students' awareness about the effects of their actions on society, or environment.

> "Students' can evaluate their own actions' effect on the nature. So, it can be said that it is morally appropriate for the students." (FI_G6_BY, ILP)

Moreover, some of the PSTs mentioned the contribution of their lesson into students' moral development. PSTs stated that since they want from students to discuss the issue from the ethical perspective, students had opportunity to use their values.

> "Also, this issue appropriate for students' moral stage due to some reasons. Thanks to cooperative learning (jigsaw method) and discussion, students can see different perspectives about this issue and they can reach own decision-making. In addition, students can think ethically, when they discuss each other in groups. For example; they can use their personal experiments, cultural values and own beliefs. As a result of this, this issue can provide students can reach own decision making." (SI_G1_DCI, ILP)

Overall, about developmental level, although PSTs realized the importance of students cognitive and moral developmental level on their SSI reasoning, they did not have much knowledge about how to develop students in terms of these issues. PSTs commonly complained in post-teaching structured interviews that they did not have much knowledge about moral development and they did not know how to facilitate students' moral development in SSI teaching.

PSTs know the role of SSI reasoning on their moral development. they thought that they can contribute students' moral development through SSI teaching

> "Students become able to make their own decision when they become mature morally. I guess, after 11 years-old, students start to think analytically. We are covering this topic at those ages. Since they can think analytically, their moral development can also be increase. Since we want students to make informed decisions through argumentation in our SSI teaching, we can contribute to their moral development." (FI_G3_FK, PTSI)

However, they were not sure how their SSI teaching may be helpful in terms of moral development. The reason may be related to the inefficiency of the groups' addressing of ethical and moral issues in their SSI teaching. As it was explained in the following section, groups were not effective in addressing moral and ethical issues into their SSI teaching. Therefore, they did not have clear idea about how to contribute students' moral development. However, they gained awareness about importance of SSI teaching in terms of moral and cognitive development of students. Therefore, in their individual lesson plans, more PSTs addressed ethical issues in their SSI teaching by using different strategies. How groups and PSTs addressed ethical and moral issues in their SSI teaching was explained below.

4.4.2. Addressing ethical and moral issues in SSI teaching

Group lesson plans and individual lesson plans were analyzed to figure out how PSTs addressed ethical and moral issues in their SSI teaching. There were different ways of addressing ethical issues. They either included an ethical aspect to the discussions about SSI or include questions to consider ethical issues in their discussions. On the other hand, they focused only the ethical aspect of the SSI. The way of groups' and PSTs' addressing the ethics in SSI teaching and the SSI topics that were resolved from ethical aspect were summarized in Table 19.

Table 19.
The Way of Groups' and PSTs' Addressing Ethics in SSI Teaching

The way of addressing ethics in SSI teaching	SSI topic	GLP		ILP		Total
		FI	SI	FI	SI	
Including ethical aspect of SSI	Organ donation	-	-	-	4	4
	Human cloning	1	-	2		3
	Stem cell	-	-	-	2	2
	Human genome project	-	-	-	2	2
	Abortion	-	-	-	1	1
	Huntington disease	-	-	-	1	1
	Using orphans as cadaver			1		1
Including questions about ethics	Animal testing	-	1	1	-	2
	Human cloning	-	1	-	-	1
Focusing only ethical aspect of SSI	Animal testing	-	-	2	-	2
	Gene therapy	1	-	1	-	2
	Organ donation	-	-	1	-	1
	Human cloning	-	-	1	-	1
	Genetic engineering	-	-	1	-	1
	Sperm donation			1		1
Total		2	2	11	10	24

Mostly, groups (n_{FI}=1) and individual PSTs (n_{FI}=2, n_{SI}=10) addressed different aspects of SSI in argumentation. They also include ethics aspect as one of those aspects. These PSTs gave students like being scientist, legislators, public, doctors, or economists. They also asked some of the students to act as ethicists.

For example, the fifth group of the first implementation addressed human cloning issue in their SSI teaching. they formed groups and gave roles to each group to resolve the SSI. They asked students to act as scientists, ethicists and legislators. In their webquest, this group included questions to be considered while resolving the SSI. For ethicists they included below questions.

> "For ethicist:
> 1)What are the potential benefits of human cloning?
> 2)What are the potential risks of human cloning?
> 3) Do we need to clone humans? Why/Why not?
> 4) Who should decide to allow or ban human cloning?
> 5) What should be the ethical standards?" (FI_G5, GLP)

Similarly, one of the PST from the second implementation addressed organ donation in her SSI teaching lesson plan. She planned to engage students discussions about the beneficial and harmful sides of organ donation and organ transplant in terms of different perspectives such as scientist, ethicist and public.

Instead of including ethics as one of the aspects of SSI, two groups from the second implementation and one PST from the first implementation asked all or some of the students some questions to consider also ethics included in their resolution. For example, the seventh group of the second implementation asked students to resolve SSI as if they were scientists, pharmacists and rule makers. They guided rule makers to consider the legislations of ethical committees to protect the welfare of animals.

On the other hand one group and six of the PSTs from the first implementation focused only the ethical aspect of SSI, rather than addressing different aspects of the SSI. For example the sixth group of the first implementation addressed gene therapy issue in their SSI teaching and wanted students to discuss whether the gene therapy ethical or not. Similarly, one of the PSTs from the first implementation planned to engage her students into discussion about ethicality of animal testing.

> "At the classroom decision we will talk about that it is just one of the controversial issues and there is no right answer about this SSI, 'Animal Testing is ethic or not'". (FI_G6_BY, ILP)

As it can be seen from Table 19, PSTs in the second implementation included ethics aspect into SSI reasoning in addition to other aspects like economics, science or legislation. On the other hand, PSTs in the first implementation mostly preferred to focus only the ethical aspect of SSI topic. However, there were some PST also in the first implementation including ethics as one of the aspect of SSI.

The topics in which PSTs addressed ethical concerns were generally genetics-related topics. Although they also covered energy-related or environmental SSI topics, they did not consider ethics in resolution of those SSI topics. They generally focused on bioethics.

CHAPTER 5

PATTERNS OF PSTs' METACOGNITIVE THOUGHTS AND TECHNOLOGY INTEGRATION PRACTICES OF PSTs INTO SSI TEACHING WITH DIFFERENT PATTERNS OF METACOGNITIVE THOUGHTS

As it was mentioned in the first chapter, an undergraduate SSI teaching course was re-designed to develop PSTs' effective SSI teaching practices with technology. PSTs' effective SSI teaching practices with technology was operationalized with TPACK framework. Considering its potential to the development of TPACK for effective SSI teaching, metacognition of PSTs was activated in the re-designed course with different activities. PSTs' were explained explicitly about the role and importance of metacognition in instructional practice. Then, they were urged to think about their thinking before, during and after their teaching performances as well as their strengths and weaknesses about their technology, pedagogy and content knowledge in general. Their thinking about their teaching was tried to be captured with the reflection papers as well as video-stimulated recall interviews and post-teaching structured interviews. Therefore, in this chapter, the relationship between TPACK for effective SSI teaching and metacognition underlying their SSI teaching was examined. For this reason, the following research question and the third and fourth subsidiary questions were tried to be answered in this chapter.

5. How effective is the re-designed course in developing pre-service science teachers' TPACK for effective SSI teaching by activating metacognition?
    a. What is the development of PSTs' TPACK for effective SSI teaching throughout the course?
    b. What is the nature of PSTs' TPACK for SSI teaching after they attended to the re-designed course?

c. What is the pattern of PSTs' metacognition underlying their effective technology integrated SSI teaching practices?
d. What is the relationship between the PSTs' TPACK for effective SSI teaching and metacognition patterns?
e. What is the contribution of the re-designed course in PSTs' TPACK development for effective SSI teaching?

In order to answer the fourth subsidiary research question, firstly, the elements that were considered as important for teacher metacognition were examined. Those elements defined in the theoretical framework of the study (Figure 4) were beliefs, technology integration knowledge (TPACK) and goals. Therefore, PSTs' beliefs and goals about technology integration into effective SSI teaching were explained. The other element, TPACK for effective SSI teaching, was figured out through analysis of their individual and group lesson lesson plans with Lesson Plan Evaluation Rubric for Technology Integration into SSI Teaching (LPER-TIST). Moreover, groups' TPACK were also figured out by analyzing their teaching performance with the help of Teaching Performance Evaluation Rubric for Technology Integration into SSI Teaching (TPER-TIST).

After the explanation of the factors affecting metacognition, PSTs' patterns of metacognitive knowledge and metacognitive regulation were described. Based on the literature and the results of this study, the following patterns were figured out about PSTs' metacognition underlying their technology-integrated SSI teaching instructional practice. Summary of the different metacognitive thoughts of PSTs were provided in Table 20.

Table 20
Summary of Patterns of Metacognition

Metacognitive Components	Group X	Group Y
	Knowledge of Cognition	
Knowledge of content	Revealed an awareness of all possible arguments about their SSI topic. Felt themselves well-prepared for possible student arguments from different aspects	Felt themselves insufficient to address unexpected student arguments
Knowledge of pedagogy	Revealed a complete confidence for their understanding of the selected instructional strategy and selected and used proper techniques and technologies to facilitate the instructional strategy	Felt themselves insufficient to plan and implement the instructional strategy
	Regulation of cognition	
Preactive Stage/ Planning	Focused on SSI reasoning processes in teaching and assessment plans. Sequenced the activities to help students be aware of multiple perspectives and the relationships of these perspectives as well as to engage them in both social and scientific inquiry. Selected proper technologies to reach those aims and integrated them to SSI reasoning processes	Sequenced the tasks illogically. Centered the plan around the processes to be followed without a clear focus on SSI reasoning processes. Planned to use technology without complete integration of them to SSI reasoning processes
Interactive Stage/ Monitoring	Observed, listened to and pursued students ideas and focused on students' understanding and quality of argumentation as well as technology usage skills	Monitored students' participation and focused on students' completion of tasks or ability to operate technological tools
Interactive Stage/ Regulating	Adapted instruction while teaching based on the information received through monitoring student progress. (e.g. give extra time for small group discussions)	Taught the lesson without any deviations from original plans or was not confident during the inevitable changes
Postactive Stage/ Evaluating	Evaluated their goal accomplishment in terms of helping students construct their own meaning, develop SSI reasoning skills and scientific and technological literacy	Evaluated their teaching only based on their effectiveness in time management
Postactive Stage/ Revising	Gave ideas about selecting more appropriate technologies to facilitate their instructional strategy or preparing more effective lesson plan	Gave ideas for better time management

All of the PSTs' were triggered to think about their thoughts about their teaching through the activities of the re-designed course, However, although none of their thoughts were superior to others, there were differences in the orientations of their metacognitive thoughts. Therefore, PSTs were categorized according to the nature of their metacognitive thoughts.

While categorizing PSTs in terms of their metacognitive thoughts, only the participants with necessary data giving information about their metacognition were included. In order to reveal PSTs' metacognitive thought, they were asked to prepare reflection paper at different points in time throughout the course. Moreover, to triangulate their written reflections, they were asked to be volunteer for video-stimulated recall interviews as a group and post-teaching structured interviews individually. PSTs may not provide detailed answers in their written reflections. On the other hand, they may hesitate to reflect their thoughts in the interviews. By triangulating different data sources, their metacognition was tried to be figured out as much accurately as possible. Therefore, PSTs were included in this analysis, if there was necessary data sources for them to be able to triangulate the findings about their metacognitive thoughts.

Since two of the groups in the first implementation could not select a proper SSI topic to teach, they could not write reflections and they could not be volunteer for VSRIs. Therefore, there were not enough data to reveal their metacognition. Moreover, in the second implementation, the participants were asked to write a simplified version of the reflection paper-2. Only the volunteer participants were interviewed with detailed questions to figure out their metacognition. Among twenty participants interviewed voluntarily, one of them did not write individual lesson plan and reflection paper 1. Therefore, 44 PSTs (25 from FI and 19 from SI) were categorized in terms of their metacognitive patterns, in total.

PSTs were not categorized in only one group for each metacognitive component. For example, while some of the PSTs were categorized in Group X in terms of their planning, their thoughts in interactive stage showed similarity to Group Y. Therefore, the numbers of PSTs falling under each group in terms of each metacognitive component were given in Table 21.

Table 21
Number of PSTs with Different Metacognitive Thoughts for Each Metacognitive Component

Metacognitive Component		Group X				Group Y			
		FI		SI		FI		SI	
		N	%	N	%	N	%	N	%
Metacognitive Knowledge	Knowledge of content	11	42	10	52	15	58	9	48
	Knowledge of pedagogy	14	54	9	48	12	46	10	52
Preactive	Planning	12	46	16	84	14	54	3	16
Interactive	Monitoring	7	27	11	58	19	73	8	42
	Regulating	11	42	10	52	15	58	9	48
Postactive	Evaluating	7	27	9	48	19	73	10	52
	Revising	9	35	17	89	17	65	2	11

After explaining the nature of PSTs' metacognitive thoughts, at the end of the chapter, the relationship between PSTs' TPACK for effective SSI teaching and their metacognitive patterns were demonstrated. In this way, it was tried to be reached evidences about the effectiveness of the re-designed course.

5.1. PSTs' Beliefs about Technology Integration

PSTs beliefs were assumed to be influential in their instructional decision. Therefore, it was proposed to have a relationship with PSTs' metacognition underlying their instructional practice. Moreover, an overarching conception about the purposes for incorporating technology in effective SSI teaching component of TPACK was defined as teachers' conceptions about what is important for students to learn and how technology supports students to learn. This component also serves as a basis for instructional decisions and it is different from other components in terms of comprehensiveness.

In science teaching PCK, this component was defined as an orientation indicating the views and conceptualizations of teachers about science teaching. In their comprehensive literature review for this component, Friedrichsen, van Driel, and Abell (2010) defined it as a set of beliefs including "goals and purposes of science teaching, views of science, and beliefs about science teaching and learning" (p.358) and mentioned it as the most frequently ignored component of teacher knowledge. However, they also urged the need for revealing these beliefs to get a more complete understanding about the teacher knowledge. They addressed some of the issues about conceptualizing this component in the PCK studies. The researchers criticized the studies using the Magnusson et al.'s (1999) framework, which is the framework also used in this study, in terms of lack of explicit expression of the role of orientations as shaping other PCK components. However, Friedrichsen et al. (2010) stated that it is important to figure out teachers' orientations and relate it to other components. However, figuring out the orientations should not mean labeling them with nine defined categories mentioned in Magnusson et al.'s (1999) chapter as always done in the literature incorrectly (Friedrichsen et al., 2010). Therefore, in this study the overarching conceptions of PSTs about technology in effective SSI teaching was tried to be figured out to see the effect of it on instructional decision and metacognition underlying instructional practice.

PSTs' overarching conceptions was retrieved mostly from their first reflection paper they prepared at the beginning of the course after the introductory lectures. In their reflection paper, PSTs' tended to think more general so that mostly their overarching conception about science in general was retrieved rather than specific to SSI topics.

As retrieved from the first reflection paper, PSTs' have different beliefs about the role of technology in science teaching and learning. Their beliefs about the role of technology in science learning and science teaching were explained differently. The codes for the role of technology in science learning was retrieved from the technology integration strategies for science categorized by Robyler and Doering (2010). According to this categorization technology can help science learning by supporting science concept learning, supporting scientific inquiry, accessing science information and tools, and supporting authentic science experiences. Moreover, according to Ertmer, Addison, Lane, Ross, and Woods (1999), teachers also stated preparing their students for future as the reason of their technology use in elementary classrooms. Therefore, another category was included.

While teachers belief about the role of technology in science learning includes the considerations about students' learning, their belief about the role of technology in teaching includes their considerations about using technology to arrange teaching and learning environment to ensure their students' learning. As Ertmer et al. (1999) mentioned, teachers use technology for five reasons. They mentioned that teachers' incentives for technology use was exciting and motivating their students, preparing their students for the future; making lessons more interesting; reaching students with learning or attention problems; and using technology for becoming more competent. Therefore, adapting these stated reasons into our study with additions; four categories were emerged from the data. These categories included increasing engagement of students, time and classroom management, becoming more competent, and assessment. The codes, categories and exemple quotations were given Table 22 together with the frequencies of the codes in different implementations.

When the frequencies of the codes about the role of technology in learning were examined, it can be concluded that PSTs mostly focused on the role of technology in supporting the science concept learning (n_{FI} = 22, n_{SI} = 20) rather than supporting scientific inquiry (n_{FI} = 3, n_{SI} = 10). They mostly admired the role of technology in allowing simulating and modelling scientific concepts. They stated that with the help of technology, learning of abstract concepts like atoms and cell division become easier for students. PSTs' thoughts about the role of technology in supporting concept learning showed similarity. On the other hand, the beliefs of PSTs from different implementations showed differences in terms of the role of technology in supporting scientific inquiry. Although PSTs in the first implementation admired only the role of technology in supporting the communications of the results of inquiry (n=2) and making the understanding of the phenomena easy through visuals (n=1), the PSTs in the second implementation also mentioned the role of technology in facilitating data collection and analysis (n=5) and collecting information to support their inquiry (n=3).

Table 22

Frequencies of Codes and Categories about PSTs Belief about the Role of Technology in Science Teaching and Learning

Categories	Codes	Sample Quotation	FI	SI	Total
		Role of technology in learning			
Supporting science concept learning	Allow simulating and modelling scientific concepts	Teaching spin of electrons around the core of an atom is difficult with drawing and students may think that electrons are rotating on an orbit. So that, this may cause some misconceptions. However, showing how they rotate with a video or a simulation will enable students to understand the topic clearly and it will prevent the misconceptions. (First Implementation(FI_G1_AG)	21	19	40
	Provide opportunities to engage in problem solving activity	Technology can be used for solving real-world problems. Studies have shown that students who used simulations, microcomputer-based laboratories, and video to connect science instruction to real-world problems outperformed students who used traditional instructional methods alone (SI_G1_AO)	1	1	2
Supporting scientific inquiry	Make data collection and analysis easier	Students should apply a variety of technologies, such as hand tools, measuring instruments, and calculators as an integral component of scientific investigations to support their inquiry. Utilizing technological tools in inquiry-based science classrooms allows students to work as scientists. (SI_G5_BKS)	-	5	5
	Supports communicating the results of inquiry	Communication platforms like Facebook and Google docs are environments that help students communicate and share their results and ideas. (SI_G2_ET)	2	2	4
	Help students obtain information to support inquiry	Students can acquire knowledge from technology related science topics via websites and presentations and they can collect data very easily only by clicking. (SI_G2_ET)	-	3	3
	Make it easier to understand the phenomena through visuals	Offering learners more responsibility and control through individual exploration and experimentation, and helping students to visualize processes more clearly. (FI_G2_AK)	1	-	1
Being prepared for the future	Developing higher order thinking skills	Thanks to using of technology in science teaching, students can have such skills that are critical thinking, problem solving and decision making (SI_G2_ET)	4	3	7
	Developing technological literacy	Moreover, children become able to modernize and they become literates of this technology age. (SI_G7_CO)	-	5	5

Table 22 (continued)

Frequencies of Codes and Categories about PSTs Belief about the Role of Technology in Science Teaching and Learning

Categories	Codes	Example Quotation	FI	SI	Total
Accessing science information and tools	Allows access to unique tools and collections of information to expands opportunities for learning	Technology makes information easy to reach: By the help of technology, students can reach information easily. For example, Internet is a huge library that we can find many source of scientific information. (FI_G7_FB)	5	5	10
Supporting authentic science experiences	Provides resources needed for doing authentic science activities	It supports learning and may create more authentic environment. For example, students may use 3D glasses in technology class to see the three dimensional vision of the galaxy. (FI_G7_CA)	1	2	3
		Role of technology in teaching			
Increasing engagement of students	Making lesson more attractive and enjoyable	If teacher know how to use technology, the lesson becomes more attractive for students to attend, since they think that technology is more engaging and entertaining. (FI_G4_EA)	13	8	21
	Catching and keeping attention	When teacher use technological devices in science lesson, students are more willing to listen the lesson and the time keeping their attention can be more and easily. (FI_G2_BU)	13	7	20
	Give responsibility to learners for their own learning	Technology can equip students to organize their learning process independently. Instead of being passive recipients of information, students become active users. (FI_G2_AK)	3	3	6
	Teaching according to the learner differences	Technology lets us better serve the diverse learning styles of our students and educate them for increasing of their intelligence. (SI_G8_EAR)	2	3	5
	Making daily life connection	I think that technology is essential to make the concept something real/ applicable for students' daily life (SI_G4_KC)	1	3	4
Time and classroom management	Saving time	Instead of drawing some diagrams, I can use power point slides or take them on the internet. So that I do not spend too much time and I cover more topics (FI_G1_AG)	15	5	20
	Changing the learning environment	Since technology supplies them dynamic environment and students' perceptions are adapted to this dynamic environment. (SI_G8_AS)	1	4	5
Becoming more competent	Networking among teachers	We can easily communicate with other students and teachers and we can standardize the education around the world to have the same opportunities. (FI_G7_FB)	3	3	6
Assessment	Assessing students' learning	Technology offers educators effective ways to assess student understanding through multiple means. (SI_G2_DB)	2	1	3
	Giving feedback	Teacher can give one by one feedback to each student (FI_G7_BB)	1	-	1

PSTs in both implementations stated that technology helps students to be prepared for the future by developing their skills. PSTs in both implementation (n_{FI}=4; n_{SI}=3) thought that technology develop students' higher order thinking skills like critical thinking, problem solving, and decision making skills. Only the PSTs from the second implementation (n=5) mentioned the role of technology integration in their development of technological literacy. They thought that since in this digital age every individual should have the ability to use technology, using technology in science lessons help them develop their technological literacy.

Another role of technology in science education was mentioned as accessing science information and tools in Robyler and Doering's (2010) study. PSTs from both implementations (n_{FI}=5; n_{SI}=5) mentioned this role of technology in learning science. They stated that technology can provide students opportunity to reach unique tools and collections of information to expands their learning. The least mentioned role of technology was supporting authentic science experiences. Only one PST from the first implementation and two PSTs from the second implementation stated that technology provides resources to students for doing authentic science activities like experiencing a three-dimensional observation of galaxy through 3D glasses.

In addition to the role of technology in facilitating students' science learning, PSTs mentioned about the role of technology in facilitating teachers' science teaching. The most frequently stated category (n=56) was the role of technology in increasing students' engagement. The thoughts of PSTs were similar in both implementations. About this category, they mostly stated that technology has an important role in making science lessons more attractive and enjoyable. They frequently (n_{FI}=13; n_{SI}=8) stated that if teacher use technology in science teaching effectively, students enjoy the lesson and their engagement increase. Similarly, PSTs frequently (n_{FI}=13; n_{SI}=7) stated that teachers can ensure students' engagement by arousing and keeping their attention through different technological tools. Since all students interested in technology, using different kind of technological tools and multiple representations arouse students' attention into science.

Although relatively less frequently stated (n_{FI}=3; n_{SI}=3), PSTs also mentioned the role of technology in increasing students' engagement by giving them responsibility for their own learning. They thought that teachers can increase students' engagement by making them active in their own knowledge construction with the help of technologies, consistent with the social constructivist learning view. Moreover, they thought that (n_{FI}=2; n_{SI}=3) teachers can increase students' engagement by organizing their teaching according to the learner differences. About this code, they mostly referred to multiple intelligence theory. They stated that using multiple representations, teachers can organize their teaching to address diverse learning styles of students. For example, teachers can use visuals to increase the engagement of students who have visual intelligence. The least frequently stated code (n_{FI}=1; n_{SI}=3) in this category was making daily life connection. They thought that if daily life connection can be established about the scientific concepts through technology, students' engagement can be increased. They become willing to learn the scientific concepts due to its utility in their daily life.

Another frequently (n=25) mentioned category of the role of technology in science teaching was time and classroom management. PSTs (n_{FI}=15; n_{SI}=5) stated that using technology can help teachers save time. In this code they reffered to gaining instructional time. That is, by illustrating the concepts and phenomena easily through the technological tools, they prevent time loss. According to them, this provides them opportunity to cover more concepts in the instructional time. The thoughts of PSTs from different implementations were different about this code. The number of PSTs who regard the technology as a tool for saving more instructional time was higher in the first implementation.

PSTs also referred the role of technology in their professional development as in Ertmer et al.'s (1999) study. They (n_{FI}=3; n_{SI}=3) stated that technology provide them opportunity to extend their network and share their ideas and good practices with each other. Therefore, these PSTs indicated social constructivist views of learning. Lastly, although less frequently stated category (n=4), PST mentioned the role of technology in assessment. They either regard technology important for assessing students' learning (n_{FI}=1; n_{SI}=3) or giving students' individual feedback (n_{FI}=1). PSTs also had difficulty in implementing technology into assessment in their SSI teaching as it was mentioned in the previous chapter. Therefore, their inefficiency in assessing SSI learning through technology may be related to their lack of emphasis on assessment in science teaching.

Although the patterns of PSTs' thoughts were similar in different implementations in general, there are some obvious differences in their thoughts as it was mentioned above. First difference was in their beliefs about the role of technology in supporting scientific inquiry. More PSTs in the second implementation regarded technology as a tool to support scientific inquiry. Second difference was in their beliefs about the role of technology in managing time. More PSTs in the first implementation regarded technology as a tool for saving more instructional time to cover more concepts. Based on these differences, it might be said that, the number of PSTs, who hold didactic orientation which was identified by Magnusson et al. (1999) with the main goal of transmitting the facts of science, was more in the first implementation. On the other hand, the number of PSTs, who hold inquiry orientation with the main goal of representing science as inquiry (Magnusson et al., 1999) was more in the second implementation.

There were also differences in PSTs' views about the teacher role in technology integration into science lessons. Some of the PSTs believed that teachers should be the learners of technology and they should effectively blend their technology knowledge with their content and pedagogy knowledge in order to integrate technology in science teaching. These PSTs thought that having technological knowledge is not enough for effective technology integration. They stated the need for having deep content knowledge and pedagogical knowledge.

> "Teachers should know content knowledge and appropriate instructional strategy and technology for teaching the topic. Because how and for which topics the technology is used is very important for integration of technology. Teachers must choose proper technology for topics." (FI_G7_DB, RP_1)

Although they valued the technological knowledge, they did not put it in center. They realized the importance of the capability of using technology for its benefit in teaching the content.

> "Teachers should have a capability of selecting the best teaching strategy according to science subject and using right resources." (SI_G5_BC, RP_2)

Their selection of technology in their lesson plans and teachings supported their beliefs. While planning, they first decided their SSI topic, then how to teach that topic. After this, they tried to boost their teaching with the help of technological tools. They were not techno-centric in their lesson plans.

> Firstly, we decided the instructional strategy. Then, we integrated technology. In order to select appropriate technology we need to think about the way we teach. We need to think about the objectives or expected outcomes of the lesson. Then we should think the applicability of it and consider using technology to make it applicable. (SI_G6_OU, PTSI)

Moreover, besides having different kinds of knowledge, PSTs also mentioned the need for teachers' enthusiasm to extend their knowledge in technology. They stated that since technology is rapidly changing, the teachers should keep their knowledge up to date.

> "It could be better if the teachers are curious and enthusiastic to learn about technological development." (FI_G5_DC, RP_1)

> "People, especially teachers, should ready to update themselves." (SI_G7_MK, RP_1)

> "In today's world everything change faster and faster and so teacher should keep up with changing world." (SI_G1_DCI, RP_1)

These PSTs also stated that the teacher is not always responsible to design new technologies for their lesson. Instead, they should also be creative user of the available resources. Besides designing tools when necessary, the teacher should also have the ability to repurpose the available tools for his/her goals.

> "Firstly, the teacher should select the topic. Then, the teachers should search for what was done related to the topic. There should be at least a documentary, a video or a blog page. There can be a blog page specific to that topic. Before trying to design a new one for the lesson, the teacher should be aware of the existing tools. For example, there can be a blog page specific to hydroelectric powerplant. These kinds of tools can give idea to the teacher. The teacher should follow these kinds of tools." (SI_G6_DT, PTSI)

As a conclusion, these PSTs valued the need for teachers to have technological knowledge and keep their knowledge up to date. However, these PSTs stated that the teacher should not be techno-centric in their technology integration. They should focus on how to teach the topic best, not on which technologies that they can use.

On the other hand, some of the PSTs believed that in order to integrate technology in science lessons, teachers should be technology experts. Although the beliefs of these PSTs showed similarity to the beliefs of PSTs mentioned above, these PSTs did not much refer to the relationship between technology knowledge and other qualifications of teachers. According to their statements, if teachers know how to operate a technological tool well, they can effectively integrate it into their lessons.

> “Teachers should know using office programs like excel, word and power point, mastering of computer, smart board and projector.” (SI_G3_BB, RP_1)

Moreover, PSTs emphasized the need for teachers to have technological knowledge better than their students did. Since they think that the teacher should be the technology expert for effective technology integration, they hesitate to use it in their teaching. One of the PSTs stated that she were afraid of using technology in teachings because of not being expert in using technology.

> “I can give 3 point for my technology knowledge in the classroom because I sometimes fear technological devices and am afraid not to be able to use these devices in front of the students. When I start to mention about technology, I am afraid to fail.” (FI_G1_BK, RP_1)

One PST’s statement about responsibility of teacher knowledge in technology integration can be given as a possible reason for this fear of failure.

> “Teacher should know how to use computer, smart board etc because students will mock the teachers when teacher don’t use technological material correctly.” (FI_G2_MBT, RP_2)

As it can be understood from these PSTs’ statements, they thought that the teachers should know technology quite well in order not to face with any challenge in front of the students. Moreover, they think that they should know technology as an expert so that they can design necessary tools for themselves. However, they rated their technology knowledge as poor. Therefore, these PSTs hesitated to use technology.

Similarly, PSTs have different beliefs about the role of students in technology integrated science lessons. Some of the PSTs stated that the students should be active users of technology, and should think, reason, discover, communicate, and take responsibility for their own learning. These PSTs emphasized the advantage of technology in allowing student-centered science teaching and learning.

> "Technology has very important effect on students-centered education." (FI_G7_DB, RP_1)

These PSTs stated that students should become active learners instead of passive recipients of knowledge.

> "When students are using technology as a tool or a support for communicating with others, they are in an active role rather than the passive role of recipient of information transmitted by a teacher, textbook, or broadcast." (SI_G8_EAR, RP_1)

They stated that students can get chance to make observations and inferences thanks to technology. Students can either do experiments through technological tools, or observe some scientific phenomena through multimedia tools if it is not possible to do real experiments. Therefore, students can actively be involved in discovery in technology integrated science lessons so that they become active learners.

> "Technology gives chance to students with observing and discovering instead of just listening to teachers." (SI_G1_EC, RP_1)

Moreover, these PSTs stated that by allowing students discover the scientific knowledge by themselves, technology give responsibility of knowledge construction and learning to the students.

> "I think that educational technology tools can help students actively engage in the acquisition of scientific knowledge and development of the nature of science. When educational technology tools are used appropriately and effectively in science classrooms, students actively engage in their knowledge construction and improve their thinking and problem solving skills." (FI_G2_AK, RP_1)

> "As future science teachers, we should apply a variety of technologies, such as hand tools, measuring instruments, and calculators as an integral component of scientific investigations to support student inquiry. Utilizing technology tools in inquiry-based science classrooms allows students to work as scientists." (SI_G5_BKS, RP_1)

Therefore, these PSTs believed that technology have potential to foster student-centered science teaching and learning. Therefore, it provides possibility for students to be active learners.

On the other hand, some of the PSTs viewed students as passive listener during technology integrated science lessons. these PSTs believed that students are passive learners who must pay attention and stay on task in the technology integrated lessons. These PSTs stated the importance of technology in catching students' attention to the presented topic, rather than in allowing active engagement of students in the learning process.

> "When teacher use technological devices in science lesson, teacher can gain students' attention and students are more willing to listen the lesson." (FI_G2_MBT, RP_1)
>
> "To show figures related to lesson (like mitosis and meiosis phases) with a video or a smart board both reducing the waste of time and captures the attention of students." (FI_G6_RO, RP_1)
>
> "Teacher can prevent interruption during the lecture thanks to technology since students are very interested in technology. Thus, teacher can provide more participation to lesson." (FI_G5_SA, RP_1)

While mentioning the importance of technology in terms of increasing the motivation of students, they mostly gave example to the increase in the attention to the lecture. They did not refer to any active role of students.

5.2. Goals of PSTs' Technology-Integrated SSI Teachings

Goals were proposed as another contributing factor to PSTs' metacognition. Therefore, their main goal in their technology integrated SSI teaching was examined. PSTs' general goals in planning and enacting their technology integrated SSI lessons differed. Some of the PSTs mainly wanted to help student construct their own meaning, develop reasoning skills, and scientific and technological literacy. These PSTs' main goal was to teach the necessary knowledge and skills to the students. Therefore, in their planning, teaching and assessment they mainly concerned with students' learning and development. In their lesson plan, these PSTs emphasized their main goal of helping students to develop reasoning skills. One of the PSTs clearly stated her goal of developing reasoning skills even in selecting the SSI topic.

> "Animal experimentation was chosen for socio-scientific issue which related with genetic engineering. Nowadays, animal experimenting is a controversial issue and while some of science people see it as an obligation, the others do not think that way. The aim of this lesson is learning students' thoughts about animal experimenting, seeing their way of thinking (emotive, intuitive, rational), and also providing students a relaxed class environment to involve them into discussion. Moreover, animal experimentation is an issue which is related with not only society but also medical technology, so this debate will also make students aware of latest social and technological news." (FI_G7_BB, ILP)

Moreover, after selecting the SSI topic, their subsequent decisions were also congruent with their main goal. Their instructional strategy selection and technology selection was determined based on their goal.

> "The most important tool in reaching our goal was onedrive. Because it was the place where students see different opinions and engaged in critical thinking. Therefore, our most important point was using onedrive in reaching our goal." (SI_G2_DB, PTSI)

Furthermore, as in the following examples, while evaluating their lessons' effectiveness, they stated their goal achievement. Since they mainly focused on developing students' reasoning skills, they evaluated their teaching based on its effectiveness in providing an environment for effective discussion.

> "SI_G1_CU: In here, the important thing was helping students to learn, discuss the topic and comprehend the concepts. Therefore, we mostly focused on ensuring this. Although the time was not enough for our activities, our teaching was effective in this regard." (SI_VSRI_G1)

> "I think our teaching was effective, because, it was totally based on speaking and discussing. We tried to monitor whether everyone was discussing or not. I think everyone could express freely what they wanted to say." (SI_G5_NFO, PTSI)

Although they might not finish the activities in the planned time, they focused on their effectiveness in engaging students in SSI reasoning. Therefore, their main goal was beyond the completion of the planned activities mentioned in the lesson flow of their lesson plans.

On the other hand, some of the PSTs mainly focused on the completion of the activities in the planned time. While planning their lesson, their technology selection was also affected from this goal. Therefore, they selected technology considering its effectiveness not in engaging students in SSI reasoning effectively, but in preventing time consumption.

> "We did not want to face with chaos in the class. And we did not want to lose our limited time. For this reason, we collected data from the facebook group pages quickly. Therefore, we used time effectively owing to technology. Facebook speeded up our data collection from the students." (FI_G8_CAY, RP_2)

Similarly, these PSTs' decisions during teaching were also affected from their goal. When they realized that they did not have much time, they tried to draw it fine the discussion without considering students' learning.

> "FI_G2_SK: We exceeded the time devoted to our activities. Therefore, we all were in search for how we can finish the lesson briefly by keeping the activities short." (FI_VSRI_G2)

Moreover, they evaluated their teaching performance based on their efficiency in time management rather than student understanding and development.

> "SI_G1_EC: We were not effective in our teaching. There were last 2 or 3 minutes. However, we could not listen one group. We needed to listen that group and make them discuss. Then we needed to wrap up the lesson. We could not mention our assignment before time finished." (SI_VSRI_G1)

Therefore, these PSTs mainly focused on the completion of tasks. Although they were effective in their teaching in terms of engaging their students in SSI reasoning and helping them understand the concepts, they evaluated their teaching as ineffective due to the time management problem. Moreover, although they could not engage students in SSI reasoning effectively, due to the limited time, they decided to skip some parts of the activities to be able to finish their lesson. Therefore, in their planning, teaching and evaluating their main goal for their lesson was the completion of the planned activities in the planned time.

A salient difference was observed in the percentages of PSTs having different goals in different implementations. While about half of the PSTs aimed to develop students' reasoning skills in the first implementation, this percentage was seventy four in the second implementation. The difference in the percentage of PSTs in different implementation was similar for the role of technology. Therefore, it can be claimed that their goals for technology-integrated science lessons was congruent with their beliefs about the role of technology in science education.

5.3. Knowledge of Cognition

As it was explained in the theoretical perspective of this study in the first cycle, teacher metacognition was proposed to include two parts indicating the knowledge base and process base of cognition, which are knowledge of cognition and regulation of cognition. Knowledge of cognition includes PSTs self-appraisal about their knowledge and abilities in technology integration into SSI teaching. While determining the components of knowledge of cognition, it was proposed to include PSTs' awareness of their own knowledge bases that are assumed to contribute their effective SSI teaching practices with technology. Therefore, their awareness about their own knowledge in content (SSI), pedagogy and technology were decided to be investigated.

In order to reveal PSTs metacognitive knowledge, commentaries of PSTs about their knowledge and abilities were retrieved from reflection papers and interviews. They were asked to rate their own knowledge about SSI, pedagogy and technology at different points. To figure out PSTs' knowledge of cognition, their judgments about their knowledge of SSI, knowledge of pedagogy and knowledge of technology were examined. Since the nature of technological knowledge differs from the nature of scientific knowledge (de Vries, 2005; Houkes, 2009), their judgments about their technology knowledge showed differences from the others.

Technological knowledge has normative components. That is, when we talk about the knowledge of technology, it often includes normative judgments. Although there are truths in scientific knowledge, technological knowledge includes knowledge of norms, rules and standards instead of truths (de Vries, 2005). Therefore, when PSTs were asked to rate their technological knowledge, they mostly referred to their effectiveness in technology usage. Although those judgments also provided a data about PSTs' thinking about their thinking while using technology in their instructional practice, PSTs' rating of their effectiveness in technology usage did not provide us any clue about their knowledge of cognition. Therefore, PSTs' rating of their technology usage rather than technology knowledge was mentioned in the components of regulation of cognition. They mostly mentioned how technology facilitated students' learning and SSI reasoning or how technology increased student' interest in SSI. For example, in the following quotation, the PST mentioned the effectiveness of their blog usage in facilitating their 5E instructional strategy implementation.

> "We have used 5E inquiry learning model and embedded each parts of the model as a step to the blog. For example step 1 is related with the engaging part and students can see what they do on the table before go on with next step. Elaboration step is planned for the producing a production as a handbook on internet. Therefore I can say our selected technology facilitate our instructional strategy very well." (FI_G7_FB, RP_2)

Therefore, PSTs' rating of their technological knowledge was decided not to be included in knowledge of cognition, although it was proposed to be included in theoretical framework of this study. Therefore, in the light of the analysis of the data, a revision was proposed for the theoretical framework that PSTs' rating of their technological knowledge does not provide us clues about their knowledge of cognition due to the nature of technological knowledge. Instead, it was decided to be mentioned in regulation of cognition, because when they were asked to rate their technological knowledge, PSTs mostly referred to their effectiveness in using technology in their teaching.

5.3.1. Knowledge of content

PSTs showed two different patterns in terms of their knowledge of content. While a group of PSTs (Group X) had complete confidence in their content knowledge, the other group (Group Y) did not have much confidence in their content knowledge. PSTs' assessments of their own content knowledge were illustrated below separately. While deciding their patterns of metacognitive thoughts, we relied on their own commentaries about their own content knowledge instead of our judgments.

- Group X: Revealed awareness of all possible arguments about their SSI topic. Felt themselves well-prepared to possible student arguments from different aspects

A group of PST revealed awareness of all possible arguments about their SSI topic. They were self-confident to deal with possible student arguments from different aspects. Even though they were not much knowledgeable about the issue before planning a SSI teaching lesson, they stated that in preactive stage of their instructional practice they read many articles and learned about all possible arguments related to the topic from different aspects. They collected evidences and examples for arguments.

> "Last year, I covered GMO with argumentation strategy in the methods course. We did not work scientifically at that practice since we did not base our arguments on evidences. We did not read much scientific articles for that course. Therefore, I think my content knowledge increased more in this lesson. Now, I know each aspects, economic, social etc., in detail. I can make explanations about each aspect by giving evidences." (SI_G5_FK, PTSI)

> "SI_G6_OU: Yes, one of our group members would be unprepared, but the rest of us were strongly prepared. Because everyone knew the details of the topic very well. I think, we meet the deficiency of our group-mate." (SI_VSRI_G6)

PSTs stated that thanks to their content knowledge they easily guided students during argumentation. According to PSTs, their confidence in their SSI knowledge increased in preactive stage due to the extensive research they were involved in. Moreover, their confidence affected their thought in interactive stage that they felt confident in guiding students in discussion.

> “We were full of confidence about the human cloning. Before the lecture, we were prepared well. We used many resources to learn the human cloning deeply. We also searched the topic from different aspects. We knew that as a teacher we had more responsibilities. We should know the subject as an expert. It will help us to guide students during the activities.” (FI_G5_DC, RP_2)

> “We, as teachers in the teaching performance, had the knowledge about DNA, gene and gene therapy biotechnology. Our knowledge increased compared to our prior knowledge in previous years. We were aware of using biotechnology in the gene therapy and we could not live difficulty to find cases including gene therapy. For this reason, we had confidence while explaining issues and making class environment during discussion phase.” (FI_G6_SET, RP_2)

> “We also gave directions well. When they have questions, we answered their questions effectively because we were well prepared.” (FI_G8_AD, RP_2)

They stated that they effectively guided students to think about counter-arguments. When they constructed an argument, PSTs effectively guided students to think from the opposite side, so that students became aware of counter-arguments.

> “For example, when students find an argument, we were saying the counter-arguments. We said students to think also from this perspective and made decision then.” (SI_G7_MK, PTSI)

> “FI_G8_ME: We also knew what the opposite group could say. We helped also students to consider these by saying that they can respond to your arguments like this.” (FI_VSRI_G8)

Moreover, since they were knowledgeable about the possible arguments, according to their statements, they effectively pursued students’ ideas and addressed those ideas in collective decision-making.

> “During preparation part (before teaching) we have tried to investigate all possible arguments and during teaching part we were not surprised because we have already found all of these arguments. We have easily linked all students’ arguments to the conclusion.” (FI_G1_BK, RP_2)

> “Before the activity, we had a good depth of knowledge of our topic, which helped us to have no problem dealing with the arguments presented in the class. So, knowing most of the points well, we took the arguments into account easily as the students formed and supported them.” (FI_G6_BY, RP_2)

Since they were self-confident in their content knowledge, PSTs stated that they were also confident in regulating the lesson. They were comfortable in adapting their students to argumentation process.

> “We, as teachers, prepared ourselves thoroughly considering the possible questions and different outcomes for SSI. During the activities, this preparation helped us while students from different groups were supporting their claims and objecting to the others. We could create a good discussion environment. We asked and were asked many questions from different points of views. So, knowing more than needed about the topic helped us to adapt easier which resulted in a discussion environment more comfortable both for students and us.” (FI_G6_BY, RP_2)

One of the PSTs who utilized panel at the end of their instructional practice considered all of the possibilities in helping the students in decision-making. Since he was prepared for all possible arguments, he effectively guided the panel by using effective prompting questions. the PST explained her preparedness for different situations as in the following excerpt from the VSRI.

> “SI_G6_DC: I wrote many thing like formulas to the paper. My notes included not sentences, but something weird showing what I can do in which case.
> SI_G6_DT: There were probabilities. For example, what happens if two groups disagree and one group agree etc.
> SI_G6_DC: But I already memorized most of them.” (SI_VSRI_G6)

To sum up, these PSTs were confident in terms of their knowledge in the SSI topic. They realized that their confidence increased in the preactive stage of their instructional practice, since they searched for the arguments related to their SSI topic in detail. Moreover, they were also aware that their confidence in SSI knowledge increased the quality of their instructional practice.

- Group Y: Felt themselves insufficient to address unexpected student arguments

PSTs in Group Y felt themselves insufficient in terms of their content knowledge. According to their statements, they did not have mastery in terms of the arguments of the SSI topic from different perspective or in terms of the scientific background of the topic as in the following example statement.

> "SI_G7_HK: Actually, I had limited knowledge related to our issue. When I read the references, I realized that I should think in broader perspective." (SI_VSRI_G7)

During preactive stage of their instructional practice, some of the PSTs had realized that they had limited knowledge and need to learn more about the topic. Although, they tried to learn more about the topic, they rated themselves poor in terms of content knowledge like in the following quotation.

> "Actually, we didn't have enough knowledge about the issue at the beginning of our preparation level. We tried to learn the content while we were planning the lesson. We have realized that we didn't deal with socio scientific issues as much as it's needed." (FI_G2_BU, RP_2)

PSTs generally stated that since they were not responsible for finding arguments in their job share, they were not confident in their content knowledge. Since they prepared their first lesson plan as group, some of the groups did job share. According to their statements, while some of the group members were responsible for linking the lesson plan to the curriculum, others were responsible for finding resources about their topic or for finding appropriate instructional technology. Therefore, some of the PSTs did not read much about the topic.

> "About my content knowledge…Actually, today, I was just co-teacher, because I focused more on the first part of the lesson plan. Other group members were more knowledgeable. I have general knowledge about the topic." (SI_G2_ET, PTSI)

The PSTs who were not much confident in their content knowledge referred the effects of this situation to their thoughts during interactive stage of their instructional practice. For example, some of the PSTs stated that although they thought that their content knowledge was sufficient before teaching, they realized their deficiency in content knowledge during teaching.

> "Actually, before teaching experience, we studied and searched about our socio-scientific issue (Biotechnology and genetic engineering (GMOs)) a lot but while I was teaching the issue, I realized that I was worried and did not feel so confident because students can ask challenging questions. Therefore, I realized that the socio-scientific issues can be more difficult compared to science topics in teaching procedure for teachers." (FI_G2_AK, RP_2)

> “SI_G1_AO: Yes, they asked that but I did not know. I thought what the year of the Hasankeyf video was. Then, I tried to make up an answer. I tried to guess when it had completed and I answered accordingly. I still had doubts in my mind... I did not have much information, because I did not studied much. ” (SI_VSRI_G1)

> “SI_G1_EC: (*PST stopped the video)* At that moment, I was saying to my group member that I did not have much mastery in the topic, support me in the discussion part.” (SI_VSRI_G1)

PSTs stated that their lack of knowledge decreased their effectiveness in addressing student arguments. Therefore, they could not guide their students in argumentation.

> “I had difficulty in thinking from both sides during discussion. I was quite confident in my knowledge from health aspect, but I could not think from both side in terms of ethics. Therefore, I could not help students much.” (SI_G4_KD, PTSI)

To sum up, these PSTs generally were not confident about their SSI knowledge. There were difference reasons for this situation. Some of them did not try to increase their content knowledge about the SSI topic so that they did not much confidence. On the other hand, some PSTs invested time and effort to increase their SSI knowledge. However, while reading the articles they realized their deficiency and lost their confidence to their SSI knowledge. Moreover, some of the PSTs were confident about their SSI knowledge before teaching, but while implementing their lesson plans they realized their knowledge deficiency when trying to respond student questions.

When we examined the numbers of PSTs in different implementations in terms of their knowledge of content, we realized some differences. The percentage of PSTs who were self-confident in terms of content knowledge (Group X) was more in the second implementation. The PSTs in Group X mostly stated that they developed a good understanding about their topic during the planning stage. According to PSTs, they searched about the details of the issue from different aspects and increased their content knowledge. In the second implementation, PSTs were devoted an additional half hour to explain their selected SSI topic to the classroom before their teaching. To present the details of the issue to the classroom in a systematic way, they needed to do a research. They read lots of articles and reports concerning the different aspects of the issue. Thus, it can be claimed that the revision done in the last prototype reached its aim that PSTs' confidence in their content knowledge increased in the second implementation.

5.3.2. Knowledge of pedagogy

PSTs showed two different patterns in terms of their knowledge of pedagogy. According to PSTs' statements, while a group of PSTs (Group X) had complete understanding of the selected instructional strategy, the other group of PSTs (Group Y) was insufficient in their instructional strategy knowledge. Their thoughts concerning their own pedagogical knowledge was explained below separately.

- Group X: Revealed a complete confidence about the selected instructional strategy and selected and used proper techniques and technologies to facilitate the instructional strategy

Some PSTs stated that they revealed a complete confidence of the selected instructional strategy to teach SSI through argumentation and selected and used proper techniques and technologies to facilitate their SSI teaching through argumentation. At the beginning of the course, when PSTs were asked to rate their PK, most of them stated that they took necessary method courses and learned the instructional strategies theoretically as in the following example.

> "I am really interested in method courses and educational science courses. Moreover, my grades and feedbacks caused me to think that my pedagogical knowledge is somehow good." (FI_G1_MK, RP_1)

Moreover, they stated that since they searched about argumentation before this course, they felt confident in their pedagogical knowledge.

> "We learned argumentation last year. This year, I addressed argumentation as a strategy in this year's method course. I searched intensively about it. I think I am quite good in argumentation." (SI_G1_DCI, PTSI)

> "Before teaching, I was quite sure about my knowledge on argumentation, because I read many articles related to argumentation. I knew that small group discussion is effective, and there is a need for decision-making. This decision can be conditional or all of the students

> may argue the same thing. Teacher should guide students in reaching the correct information, because there is information pollution and teacher may provide sources to solve this. If there is a discussion, there is a need for constructing claim and find evidence for this claim." (SI_G6_OU, PTSI)

However, although PSTs have theoretical knowledge, some of them were not hundred percent sure about their practical knowledge. Therefore, they rated themselves rather lower in pedagogical knowledge due to their need for experience. PSTs stated that this course was a medium for gaining experience. Therefore, after encountering difficulties and observing other groups' good and bad practices, they became more confident in their pedagogical knowledge.

> "If we were asked to rate ourselves from one to five, I could give myself four, because we still would face some problems in practice. We have already faced difficulties in our teaching performance, yesterday. Since I have seen such kind of difficulties in our teaching, I am now more confident. If you had asked me yesterday, I was not this much confident. Because I saw what kind of difficulties we could face, I gained more knowledge about how I can guide my students. Thus, I am more confident after our teaching practice. (SI_G2_DB, PTSI)

Moreover, the instructors' feedbacks about their teaching practice caused an increase in PSTs confidence in their pedagogical knowledge.

> "During the presentation, our professor encouraged me about guiding students and gave positive feedback to me. It supported me for my future guidance. Now I feel myself good in argumentation and other techniques that are suggested in Turkish curriculum." (FI_G7_FB, RP_2)

Some of the PSTs stated that they had learned argumentation in this course. Since they did not take the method course, they did not have any theoretical or practical knowledge related to argumentation. However, as in the following quotation, participants stated that they searched about argumentation to learn the theoretical foundations of argumentation. Moreover, by observing other groups they also got a sense of implementing it in classroom.

> "I did not know much, since I did not take the second method course. I learned argumentation this semester by observing previous teaching performances. Moreover, I also got methods course notes of my

> classmates. Now, I think I am quite good at argumentation. I think, I know important points of argumentation that require consideration during planning and teaching." (SI_G6_MCO, PTSI)

Based on the PSTs' statements, we can argue that the course was effective in terms of giving PSTs chance to gain experience in implementing argumentation. Therefore, their confidence to their argumentation knowledge increased thanks to the increase in their experience.

- Group Y: Felt themselves insufficient to plan and implement the instructional strategy

On the other hand, some of the PSTs felt themselves insufficient to plan and implement argumentation. One of the PSTs who did not feel herself confident in her pedagogical knowledge did not take the method course. Therefore, she did not have knowledge about argumentation.

> "I am not sure. I mostly dealt with instruction. I did not have mastery about argumentation. As I said there is a course in which argumentation is taught and I have not taken it yet. But the other three group members took that course and they guided me in teaching. Then, after our teaching, I made inference about what argumentation is." (SI_G3_AFE, PTSI)

Some PSTs stated that they did not have enough theoretical knowledge. Although they learned argumentation in method courses in the last year, they stated that they forgot what they learned about argumentation.

> "All my knowledge stayed in the last year, in the method course. I am not sure about my knowledge of argumentation." (SI_G7_HK, PTSI)

> "As far as I remember from the lesson plans we prepared in the last year, we need to create a disequilibrium in student mind by providing surprising cases from daily life. We expect from students to reach a decision by searching and discussing. But while doing these, students need to create their own claims and evidences. Then, they need to find opponent ideas to their own ideas and try to defend their ideas toward those opponent ideas. However, I am not sure about my knowledge." (SI_G5_BKS, PTSI)

Some of them stated that although they thought that they know argumentation theoretically, they were not sure about their abilities in implementing.

> “Actually, I am not sure. All of my knowledge about argumentation depends on memorization, not internalized knowledge. Giving time for discussion, being fair in letting them talk, monitoring and assessing what is talked…Doing all these things at the same time in such crowded classrooms is difficult for me. Although I know it theoretically, it is not a strategy that I can implement. I think I will have difficulty in implementing argumentation.” (SI_G3_BB, PTSI)

The PSTs who rated their pedagogical knowledge as insufficient stated that they had lack of experience in real classrooms. Therefore, they could not be sure about their abilities.

> “I cannot say I am bad. But I need experience.” (SI_G7_IT, PTSI)

> “Pedagogical knowledge little differs from the content knowledge because this is a generic form of knowledge that is involved in all issues of student learning, classroom management, lesson plan development and implementation, and student evaluation, rather than knowledge of theories, concepts or facts related to subjects. I see myself inadequate in pedagogical knowledge due to insufficient experience. I know what do I do but in practically, I have little anxiety.” (FI_G6_SET, RP_1)

Although some of the PSTs could not be sure about their abilities in implementing argumentation due to the lack of experience, some of them experienced the difficulties in implementation. Therefore, they saw where they might face with troubles. By analyzing their performance, they decided that they were not sufficient to implement argumentation in their classrooms as in the following statements.

> “I think that we are generally good at managing the classroom while encouraging the classroom discourse, but this is not enough. In argumentation part of lesson, we could be better in guiding students as a facilitator and we could ask more questions and encourage them for discussing.” (FI_G2_AK, RP_2)

> “We were not very confident and effective that we possess in-depth knowledge of argumentation since we could not take students' evidences effectively. We did not ask effective questions to students for providing good discussion environment, so the quality of students’ arguments was not very good. They were not volunteers to attend the argumentations. The reason of this situation may be our questions. Of course, they argued the topic, but they were not good at providing evidences to their ideas.” (FI_G5_SA, RP_2)

One of the PSTs stated that although she had some basic theoretical knowledge about argumentation, she learned some practical knowledge through their teaching practice.

> "If you ask what I learned, I can say that I learned how to pose questions to the students as a facilitator. I learned how to manage the whole class discussion. I rate my argumentation knowledge as medium-level. Since I have difficulty in deciding the extent of the information I should give to students or the procedures for grouping and distributing the roles to the students." (SI_G4_KD, PTSI)

Moreover, some of the PSTs realized that they had difficulty in managing the argumentation, although they thought that they had enough knowledge about the SSI topic.

> "Although we, as a group, searched and studied our socio-scientific issue a lot before teaching experience, I did not feel so confident because I realized that I had difficulty in managing and monitoring class in argumentation part of lesson." (FI_G2_AK, RP_2)

Some of the PSTs had concerns about implementing argumentation in their future career. Although PSTs thought that they were quite effective in their teaching performance, they had still doubts about their ability of implementing argumentation in their future classrooms.

> "It was so difficult. Fortunately, our classmates had awareness about argumentation strategy and we did not face big problems. However, I think there would be many problem in implementing in real classrooms. I do not trust myself how I can manage the classroom in such chaos. I think we were quite effective, because our classmates were so thoughtful." (SI_G5_NFO, PTSI)

Another reason for their deficiency in their self-confidence in argumentation was their accustomedness to traditional teaching methods. Since they were not accustomed to instructional strategies in which teacher has a role of facilitator, they were not much confident in implementing argumentation as in the following excerpt.

> "FI_G1_SKO: I think the instructional strategies requiring facilitator role of teacher are more difficult. Managing the time and the classroom requires much more workload for teachers. Direct instruction is easier. Okey, it is not a preferred instructional strategy, but being facilitator is much harder for me". (FI_VSRI_G1)

Moreover, PSTs mostly rated their knowledge of argumentation low due to the problems they faced in reaching a common classroom decision about the SSI topic. As it was mentioned in explanations of the groups' teaching performances, guiding the discussion during for collective decision-making was the most difficult part for PSTs. They observed each groups' difficulty in that part. Therefore, their confidence to accomplish this part became lower as in the following example.

> "I am still not much confident. We tried to do our best as far as we know. However, for example, what we did in the conclusion part did not work. We need to find something for that part. We are deficient in that part. We are coming well until the end of the lesson, but we are deficient in the conclusion part of argumentation." (SI_G5_FK, PTSI)

The numbers of PSTs from different implementations showed similarity in terms of their metacognitive thoughts concerning their pedagogical knowledge. While about half of them felt themselves confident in terms of pedagogical knowledge, half of them were not self-confident. However, there is a difference in the source of their beliefs about their own pedagogical knowledge. Since most of the groups in the second implementation were better in implementing argumentation compared to the groups in the first implementation, they observed the difficulties that are likely to arise during the implementation of argumentation. Although PSTs rated their groups' performance as effective, they started to be concerned about their capabilities of implementation in their future classrooms. On the other hand, PSTs from the first implementation made general comments about their pedagogical knowledge without experiencing it.

5.4. Regulation of Cognition

In addition to their knowledge of cognition, PSTs' thoughts before, during and after teaching performances were also examined and then general patterns of their metacognitive regulation during preactive, interactive and postactive stages of instruction were determined. Summary of the patterns of PSTs' metacognitive thoughts was included in Table 20. Group X and Group Y represents the groups of PSTs who have different metacognitive thoughts. However, neither of them superior to each other. The differences in PSTs' metacognitive thoughts in terms of each component were explained below.

5.4.1. Preactive stage – Planning

PSTs differed in their thoughts during lesson planning. While some of the PSTs (Group X) focused more on students' SSI reasoning and planned activities to ensure this, others (Group Y) did not consider the contribution of the activities on SSI reasoning. Different groups' thoughts were explained below.

- Group X: Focused on SSI reasoning processes in teaching and assessment plans. Sequenced the activities to help students be aware of multiple perspectives and the relationships of these perspectives as well as to engage them in both social and scientific inquiry. Selected proper technologies to reach those aims and integrated them to SSI reasoning processes

These PSTs admired the contribution of a detailed planning in their teaching performances. According to their statements, although they were exhausted while preparing their lesson plan, multifaceted thinking about their planning resulted in self-confidence in their teaching. Since they were prepared for even unexpected situations, they felt themselves comfortable during teaching.

> "After planning, we knew exactly what we had to do and when we had to do even in the unexpected situations. Because, when a teacher uses technology integration, there should always be a back-up plan that s/he can follow." (FI_G7_OK, RP_3)

> "While planning I realized that designing a lesson plan according to TPACK needs detailed information. We spent hours on it. However, the good part is, after finishing our lesson plan; we know exactly what to do in our class, even in unexpected situations. I realized that this contributed to my self-confidence." (FI_G7_BB, RP_3)

These PSTs were elaborative in their planning. They considered many variables like students background, facilities of the classroom, their own skills, as well as the requirements of the selected SSI topic. These PSTs considered their goals during their planning. Therefore, they tried to plan activities to reach their goals. Since they were asked to teach an SSI topic, they created an argumentative discussion environment. Therefore, they planned activities to boost the discussion environment.

> "While planning, we aimed to create a discussion environment but before that, we wanted to give students a chance to collect information and evidences. Therefore, we made things clear and easy for them by giving them sources that they could use." (FI_G7_OK, RP_3)

> "I think that planning has an important role for the effectiveness of the teaching. Before applying the technology in science teaching, as a teacher you need to consider some points. I know that I should consider my classroom environment, my students' grade level, their skills, and what kind of technological instruments I have. Based on these factors, I planned my lesson plan. If I ignore one of them, I would face with some problems about technology integration." (FI_G5_RD, RP_3)

While planning, these PSTs thought about the requirements of SSI teaching. Then, they planned activities to employ those requirements.

> "In our lesson plan, we tried to allow students to do research about the socio-scientific issue. For this reason, we planned to use the computers with internet. Moreover, we used a common website that was OneDrive.live.com and we considered that the using online platform can be easily understood by students. So, when we chose the website that used commonly by each student groups, we took into account the possibility of students communication with each other in the discussion." (FI_G6_RO, RP_3)

- Group Y: Sequenced the tasks illogically. Centered the plan around the processes to be followed without a clear focus on SSI reasoning processes. Planned to use technology without complete integration of them to SSI reasoning processes

On the other hand, PSTs in Group Y only focused on the technologies planned to be used without any emphasis on the SSI reasoning. According to their statements, while planning, they first decided the technologies planned to be used. Then, they planned the lesson flow based on the technologies.

> "Before the lesson, when we prepared the lesson plan, we planned what technological tools could be used in the lesson and we consider the appropriate technologies in order to integrate the lesson and also how to be used them. This provided us having an opportunity that we learned all knowledge about the technology and how we can use them correctly.

> We considered that some limitations and difficulties due to technology could occur during the lesson." (FI_G2_SK, RP_3)

Since they viewed the technology usage as the main goal of their lesson, they only focused on how technology can be used without commenting on its necessity.

> "While planning, we prepared a OneDrive page for discussion. We tested them before teaching. We have alternatives for it; if we would not have used OneDrive. However, when we did not use OneDrive, we would not have applied any technological tool. Therefore, we could not reach the aim of the lesson, which was technology integration." (SI_G3_BB, PTSI)

Therefore, in their planning, they mostly elaborated how they can use technology in an effective way, instead of mentioning how they can make their instructional strategy more effective with the help of technology.

> "I thought about what technological tools are useful in our lessons and how they can be used in effective way. Also I thought whether students can achieve the usage of these tools, they can operate that well, they can finish the tasks at time and how this tools help our students in their cognitive improvements." (FI_G8_AD, RP_3)

One of the PSTs even stated their difficulty in integrating technology into their lesson plan, the revisions in the plans to integrate technology. Therefore, the PST stated the importance of technology and the necessity of deciding the technologies before preparing the plan.

> "I think we should have decided the instructional technologies first. We decided to prepare a lesson plan and then integrate technology into it. However, we needed to change the lesson plan, because we could not integrate technology. Therefore, I think, technology is more important." (SI_G1_AO, PTSI)

However, this group and this PST criticized their technology usage and offered revisions for the selected technology. After evaluating their teaching performance, they realized that they used excess amount of video and this caused distraction.

There was a difference in PSTs' metacognitive thoughts in different implementations in terms of this component. While less than half of the PSTs (46%) in the first implementation were in Group X, 89% of the PSTs in the second implementation were categorized in Group X in terms of their thoughts during planning. This difference showed similarity with the differences in their beliefs about the role of technology and the role of student, and their goals of the lesson. Therefore, if they believed that technology has vital role in making students active in their learning, and if they aimed mainly to engage their students in SSI reasoning, they considered all these in their lesson plans. PSTs' lesson plans and the differences between the lesson plans of PSTs from different implementations were elaborated in the previous chapter.

5.4.2. Interactive stage – Monitoring

According to PSTs' rating of their ability to monitor students during teaching, they showed differences in monitoring. While a group of PSTs (Group X) was quite confident in their monitoring skills, other PSTs (Group Y) could not go beyond observing students' completion of tasks. In order to monitor their teaching, PSTs monitored students' progress in the lesson. Therefore, their monitoring of students gave them clue about their own performance. Monitoring skills of the two groups was explained below.

- Group X: Observed, listened to and pursued students ideas and focused on students' understanding and quality of argumentation as well as technology usage skills

PSTs in Group X observed, listened to, pursued students' ideas, and focused on students' understanding and quality of argumentation. During small group discussions or whole class discussions, these PSTs effectively monitored students and followed their arguments. To monitor students' argumentation skills effectively, PSTs took advantage of technology. They created an online word page including a table to be filled by the groups as mentioned in the following quotations.

> "I had a chance to follow how students write pros and cons and support them with evidences. Students were also expected to fill a worksheet. I also tried to control their arguments from there." (SI_G3_BB, PTSI)

> "We were good in following students and addressing their ideas during the lesson and argumentation. We have established proper tools in blog

> to follow them. To evaluate the quality of students we have given data table to students and inform them how they fill it. Therefore, all groups could see the other groups' claims and evidences and prepared themselves accordingly. This table was very useful for me to follow and link groups' claims and evidences together." (FI_G7_FB, RP_2)

These PSTs effectively guided small groups in discussion by posing questions. They monitored the content of students' arguments and asked them to find evidences to support their claims.

> "Yes, we monitored each group personally. I guided students by asking such kind of questions that why did you say like this, do you have any evidence to claim this argument, if you have, write those evidences below your claim. Look, the opposite group said like this, how can you refute this, what evidences can you provide to refute other groups' claims." (SI_G7_MK, PTSI)

In addition to small group discussions, during whole class discussions, these PSTs effectively listened to students' arguments and directed questions to the related groups to guide them to respond to the arguments. In order to help students follow the discussion, the PSTs restated the student arguments.

> "FI_G7_EY: The most difficult thing in discussion for student is to understand other groups' arguments. The teacher should explain arguments to the class. Students either cannot listen or cannot give related evidences. Therefore, I tried to restate students' arguments in a more simple way. One student's argument was not understood. Everyone looked for a second. Then, I directed the discussion to society group." (FI_VSRI_G7)

> "Our group member, who managed the panel, monitored students' ideas and managed the discussion effectively. When a student said a claim, he asked other students that what do you think about this argument, what can you say to refute this argument." (SI_G6_OU, PTSI)

As in the previous quotations, the PSTs were able to monitor students to decide whether they could follow the discussion or not. PSTs thought that they could easily and effectively monitored students' understanding and tried to help them understand the arguments.

Moreover, these PSTs were good at monitoring students' technology usage. They stated that they easily monitored students' progress in technology usage and determined the difficulties they faced related to the technology. Then, they tried to provide solutions to their problems.

> "SI_G3_AFE: one of the students had difficulty in signing in the onedrive page. The student could not sign in the online word document and when the teachers started to write something on their groups' page, the student surprised and gave up trying to sign in. we spend many times to troubleshoot their problems." (SI_VSRI_G3).

On the other hand, one of the PSTs monitored students' technology usage effectively and decided that students did not have any problems about using technology. This PST was aware of teachers' difficulties in monitoring students' technology usage based on the literature. The PSTs realized that they did not faced with these kind of monitoring problems due to the simulated classroom environment in which their peers pretended like students. However, the PST thinks that they would face such kind of problems mentioned in the literature in their real classroom experiences.

> "We did not have any specific problems with students, I think it is because our age, however in K-12 students we might have different kinds of issues. According to Digedu article; 46% of teachers report lacking adequate training on technology they use. 51% of teachers report lacking adequate support for technology they use. 48% report a loss of class time due to technology issues. 33% of teachers report lacking adequate visibility into what students are doing when they are using technology (2014). Even though, we did not have any kind of trouble, I am aware of we will have in real class discussion with students." (FI_G7_BB, RP_2)

- Group Y: Monitored students' participation and focused on students' completion of tasks or ability to operate technological tools

On the other hand, during small group and whole class discussions, some of the PSTs monitored students' participation and focused on students' completion of tasks or ability to operate technological tools. Although they observed that students are participating to the group discussions, they did not observe the content of the discussion. They did not follow any students' ideas in the discussion. Therefore, they could not guide the discussion effectively as it was mentioned in the following quotations.

> "I think that we were not effective in following and addressing students' ideas throughout the lesson because we saw that monitoring students' discussion and cooperative workings of them are difficult tasks for teacher. Teacher should follow all students and their activities, discussion, and s/he should give directions and feedbacks in the teaching procedure for effective teaching. We understood that this is not easy and teacher should prepare very well when s/he teaches especially the socio-scientific issue." (FI_G2_AK, RP_2)

> "We could not follow and address students' ideas throughout the lesson and so the groups could not discuss their ideas effectively." (FI_G5_SA, RP_2)

> "I always walked around and when I see someone looking around for help I asked them what is their problem. However, since I always walked around and did not monitor the groups deeply, I could not have chance to learn what they were discussing." (SI_G7_HK, PTSI)

Their difficulty in monitoring students' arguments was generally caused due to either they were not much knowledgeable about the possible arguments about their SSI topic, or they did not know argumentation well.

> "I cannot say that I am effective in monitoring. I did not know the evidences well. Therefore, I could not observe what they discussed. I just observed whether they are participating to the discussion or not." (SI_G1_EC, PTSI)

> "If I were the only teacher in the classroom during discussion, I would have difficulty. Because there were six groups and the students in the groups discussed their ideas at the same time. I should guide them. It is a really difficult job." (SI_G7_HK, PTSI)

Since PSTs did not have a wide acquaintance with the arguments related to their topic, they had difficulty in keeping students' arguments in mind as they stated below.

> "We were not very effective in the following students' ideas because we could not keep in mind the previous groups' ideas and we forgot. Therefore, we were not efficient." (FI_G1_SKO, RP_2)

Instead of focusing on the students' arguments, these PSTs generally monitored whether students were participating in the discussion, searching for the evidences from the internet. They stated that they frequently checked students' monitor, whether irrelevant websites, like social media, were open or not.

> "We were continuously going around the class while students were studying. Therefore, we were aware of what they were doing etc." (FI_G2_BU, RP_2)

> "We walked around the groups to be sure whether students search about gene cloning from internet and participate in the discussions or not." (FI_G2_AK, RP_2)

> "Each of the teacher was observing whether students were chatting on WhatsApp or whether they were busy with something else." (SI_G3_AFE, PTSI)

There was a notable difference between the groups from different implementations in terms of monitoring. While only 27% of the PSTs from the first implementation stated that they effectively monitored students' progress, 58% of PSTs from the second implementation rated their monitoring as successful. As it was explained in the previous chapter, the groups in the second implementation were better in performing argumentation. Since they had better argumentation knowledge and better practices about it, they were more confident in monitoring students' progress throughout the argumentation activities. Moreover, as they also stated, their monitoring skills were related to their confidence in their knowledge about SSI topic. Since the PSTs in the second implementation were more confidence in their SSI knowledge, they rated their monitoring as effective. Knowing all the possible arguments related to the SSI topic, PSTs easily monitored students whether they were effectively participating the discussion with quality evidences. Moreover, they could easily pursued students' arguments in discussions, because they were aware of all possible students arguments.

5.4.3. Interactive stage – Regulating

PSTs showed differences in their regulating skills. Their regulation during teaching was explained for Group X and Group Y, separately.

- Group X: Adapted instruction while teaching based on the information received through monitoring student progress. (e.g. give extra time for small group discussions)

There was a high relationship between monitoring and regulating skills. If PSTs effectively monitored the progress of the students, they decided to make changes accordingly. Some of the PSTs effectively adapted instruction during teaching based on the information received through monitoring student progress. Most frequently, they had to make regulations about timing of the activities. If they decided that groups needed more evidences to support their claim, they extended the research time instead of asking them to stop group discussions and start classroom discussion without clear and scientific evidences. Therefore, they regulated the timing of the activities to increase the effectiveness of the argumentation as they stated below.

> “We followed our lesson plan, but we could not decide how to make students discuss their arguments in our lesson plan. Students discussed in their small groups for a half hour. Then, group leaders explained their arguments to the class. We always talked with each other to decide to proper flow for the rest of the lesson during our teaching. We did not have much time after listening the group leaders. But we need to give them extra time for finding further evidences. Then, we decided to give extra two minutes to discuss within their groups.” (SI_G1_CU, PTSI)

> “We couldn’t apply our lesson plan exactly. In the lesson plan, we thought that 15 minutes was enough to complete all webquest activity. If needed, we also thought to give 2-3 more minutes for the activity. But it didn’t happen like that. 15 minutes were not enough to complete activity and share their ideas in dropbox. We had to intervene to lesson flow. So, we skipped some parts that planned before to focus more on discussions.” (FI_G5_DC, RP_2)

Moreover, if PSTs observed that student had difficulty in reaching class decision, they decided to give extra time to discuss in small groups to revise their thoughts based on the provided claims and evidences.

> “We gave extra time for that part. When we discuss the group arguments as a class, we saw that one group has opposite idea to the other two groups. We then gave 2 minutes to each group to find evidences to refute other groups’ claims or change their ideas by analyzing the evidences of the other groups.” (SI_G7_IT, PTSI)

Some of the PSTs decided changes during teaching based on their observation of previous teaching performances. They decide to skip some step to decrease the possibility of chaos and to prevent distraction of students’ attention in large groups. Therefore, they decided not to let opposite groups to come together for discussion.

Instead, they asked each groups to select a representative to represent their groups' ideas. Therefore, they aimed to increase the representativeness of each group's ideas.

> "Our lesson plan and teaching practice was congruent with each other theoretically. I mean, except for the lesson flow of the lesson plan, we utilized everything we mentioned in the lesson plan. But we decided to change the procedure in teaching practice. Similar to the previous group, we also planned to make opposite groups discuss their ideas before the whole class discussion. But we skipped that part. We called the representative of each group to the board before letting the opposite groups discuss their ideas with each other. We observed in previous teaching practice that when the opposite groups come together, the resulting group becomes too large to allow each individual students' participation. Some of the students became passive inevitably. Since the representative of the unified group could not listen each student's ideas effectively, they could not represent other students' ideas. Because they could not hear the passive students' ideas. Instead, we decided to let the representative of each small groups to discuss their ideas in front of the classroom." (SI_G6_MCO, PTSI)

One group of PSTs made regulations in the implementation procedure of their instructional strategy. Then, they adapted their lesson flow accordingly.

> "During jigsaw activity, we had to change our activity plans. Actually, we had thought to choose a representative or a stakeholder from each group and they would have explained and shared their group ideas with other groups by exchanging their group representative. So, the opinion of exchanging stakeholders of each group was what we changed during the lesson. We tried to adapt this change during the lesson especially for the discussion part. Our discussion part's talks and actions were based on exchanging of representatives. When the plans were changed, our talks and actions were changed accordingly. So, unexpected change of our plan did not have a big effect on our confidence for the planned activity." (FI_G6_BY, RP_2)

Moreover, PSTs decided some regulations related to technology usage. They decided to skip using some technological tools like videos, animations, online quizzes etc. due to time limitation. If they encounter a technical problem about a technological device, they planned to skip it or find alternative technology, based on the role of technology in their lesson flow.

> "The smart board was non-operational. Instead of this, we used white board. We used the smart board as a projector. We were very confident

> in this change. Because we could produce solutions for non-expected conditions.” (FI_G7_DB, RP_2)

> “FI_G7_FB: We decided to skip an activity. I need to show a video related to the history of vaccination. However, when the instructor asked us to pass to the argumentation part, I skipped that video.” (FI_VSRI_G7)

To sum up, PSTs decided to make changes in their lesson flow based on the information they collected through monitoring their students’ progress or monitoring the challenges in other groups’ teaching practices. Moreover, they were also able to do regulation about using technological tools.

- Group Y: Taught the lesson without any deviations from original plans or was not confident during the inevitable changes

On the other hand, some of the PSTs taught the lesson without any deviations from original plans or they were not confident during the inevitable changes. They felt compulsion to obey the lesson plan exactly. Therefore, although they realized a need for some regulations in the lesson flow during teaching, they urged themselves to follow the lesson flow as they stated below.

> “We followed the lesson plan step by step, so this made us lose time. We could skip some of the parts, like writing their beliefs about vaccination.” (FI_G7_BB, RP_2)

> “In the first week, we did not deviate from our lesson plan. In the second week, we tried to conduct discussion and argumentation exactly as we planned. (SI_G1_DCI, PTSI)

These PSTs had also difficulty in monitoring the progress of students. Therefore, they could not make decisions about the lesson flow based on their observation of student understanding. If they made changes in their lesson flow, they only did it due to time limitation. In their inevitable regulations in the lesson flow due to time limitation, they were not much confident about the changes.

> “Although we were not much certain, we made some changes due to time problem. However, generally we tried to obey our lesson plan.” (SI_G1_EC, PTSI)

> "I can say that I was 50 percent sure about our regulation. I think that it will not work. We gave extra time for one group. Two of the groups finished their discussion. I got worried about what will the other two groups do, while one group was discussing for extra 2 minutes." (SI_G7_HK, PTSI)

They believed that their anxiety due to unexpected changes could be overcome with experience. They stated that since they did not have much experience to see the results of this kind of regulations, they felt anxious about necessary regulations and avoid making some vital changes.

> "I think this skill will be improved with experience. Now, I am not much sure of myself in this regard. Since I do not have much experience, if the lesson does not flow as I planned, I become panicked. I felt the same in our lesson in argumentation part. We face with problems in grouping. I became panicked at that time and did not do anything to solve the problem." (SI_G2_DB, PTSI)

Some of the PSTs decided to make regulations due to technological problems without confidence in their change. This made them feel worried about the lesson flow.

> "Our teaching was generally congruent with our lesson plan. However, of course it was not same with our lesson plan because in teaching process, we have some technological problems. Since our teaching time is limited, we made some changes in our instruction. We were not confident and felt worried." (FI_G2_AK, RP_2)

Generally, PSTs followed their plan during direct teaching parts. Since the control of the lesson was on the teacher, and the teacher can determine the pace of the instruction, PSTs did not face much difficulty in that part. However, when they started to involve students to lesson with different techniques they needed to handle some problems. Since the students started to use technology in student-centered activities, and made discussion in their groups, more time was needed than they planned. Therefore, they had to make regulations in the activities.

When we examined the percentages of PSTs in different groups, for the second implementation, we can say that the percentages of PSTs in Group X were similar in terms of monitoring and regulating. About half of the PSTs in the second implementation stated that they had confidence in monitoring and regulating skills during SSI teaching. However, in the first implementation, 42% of PSTs were self-confident in regulating, although only 27% of PSTs were self-confident in monitoring. This is because, although they could not monitor students' progress during SSI teaching, they had to make regulations due to the time limit. Their regulation was resulted not from their observation of student understanding or progress but from their feeling of the need to follow their plan. Therefore, they were confident in their regulations due to its effectiveness in helping them to complete the activities in the planned time.

5.4.4. Postactive stage – Evaluating

In post-teaching structured interviews and the reflection paper 2, which was asked to be written after teaching performance, PSTs rated their teaching in terms of many criteria. The focus of the rating of their performance showed differences. Some of the PSTs evaluated their teaching to decide whether they reached their aim, which was helping students construct their own meaning, develop SSI reasoning skills and scientific and technological literacy. On the other hand, other PSTs could not evaluate their own performance. They talked about the possible effectiveness of their activities in reaching their goals in general. However, they could not evaluate whether they reached their aim or not. Moreover, they only evaluated their teaching performance based on their effectiveness in time and classroom management.

- Group X: Evaluated their goal accomplishment in terms of helping students construct their own meaning, develop SSI reasoning skills and scientific and technological literacy

These PSTs had clear goals in their mind and evaluated their own teaching in terms of reaching those goals. They evaluated their teaching in terms of its effectiveness in developing students reasoning skills and scientific and technological literacy. Some of the PSTs mentioned their curricular goals and evaluated their teaching whether it was appropriate to reach their curricular objectives in different learning areas.

> "We were effective in reaching the objectives. In terms of science technology society environment learning area, we were effective due the topic we selected. Yeşil Yol project is related to STSE. I think we

> developed an awareness in students about the effect of human beings on the environment. Based on students' talks during the panel at the end of the lesson, I think that we reached our aim." (SI_G6_OU, PTSI)

Moreover, the same PST also evaluated their technology integration in terms of reaching their objective.

> "We used technology for our STSE objectives. We wanted students to do research about the effect of human on the nature and the relationship between human, society and environment. Students were expected to produce claims about the issue. When I saw that students wrote their own claim to Google documents, I thought that we reached our aim in technology integration." (SI_G6_OU, PTSI)

On the other hand, another PST from the same group criticized their teaching in terms of its effectiveness in technology integration as in the following quotation. One of the PSTs stated that their blog was not much functional. They provided videos in the blog to be used as evidences by students; however, students could not hear the videos effectively in the classroom environment. Based on their weaknesses in blog usage the PST stated below, this PST also offered suggestions for revision to deal with such problems as it was mentioned in 5.4.5.

> "We were not so effective in providing evidences. Since the topic was so limited in terms of evidence, we tried to provide videos. We did not provide much written evidences in the blog. the videos were not much effective in the classroom environment. Students could not hear the video. We already included written summaries under videos; however, they wanted to reach the full resource. We were not effective in this regard." (SI_G6_MCO, PTSI)

Other PSTs also evaluated their technology use in terms of making students active in research and in argument construction and providing an inquiry-based learning environment to the students.

> "I think our technology usage was very effective in applying the inquiry method. Students can search their data to support their claim and find qualifiers for their supports.
> …I think we were good in incorporating groups into the learning process by using technology. The one drive served students an opportunity to see their groups and other groups together as cursors. They could follow the writings and it encouraged them to write and engaged them to the lesson.

…Additionally in pooling, groups enjoy the voting individually and see the results at the same time.” (FI_G7_FB, RP_2)

Moreover, one of the PSTs evaluated their guidance in increasing the quality of arguments and evidences constructed by students.

> “We guided scientist, pharmacist with relevant instructions. For example, we said to pharmacist that you can address the issue from economical perspective. You are the producers of this medicine. If a problem is detected about the medicine, you have to remove it from the market and manufacture the new medicines. This could be disadvantageous in terms of economy. I always prompted the pharmacist groups like that. Therefore, thanks to our guidance, they found effective evidences.” (SI_G7_IT, PTSI)

One of the groups addressed animal testing in their teaching and aimed to develop their students’ ethical and moral reasoning in addition to other curricular goals of their teaching. Therefore, they also evaluated their teaching in terms of effectiveness in developing students’ ethical and moral reasoning.

> I am sure that we addressed ethical and moral reasoning. While providing evidences to the groups we tried to include different resources to accomplish this. Therefore, we included the policies of different countries about animal and human welfare. They researched these resources and discussed in the classroom. Therefore, we ensured that they realized the ethical concerns about animal testing. (SI_G7_MK, PTSI)

One of the PSTs monitored students’ evidences provided in the discussion. Then, the PSTs realized that although it was not their main goal, the discussions was effective in terms of developing students’ ethical and moral reasoning. As it was given in the below quotation, the PST realized that their teaching can also be used to develop students’ moral reasoning. Therefore, based on this observation, the PST suggested revising their lesson plan to emphasize this point.

> “This discussion also gave responsibility to students to consider all possible cases before making decision. During the argumentation, one group talked about testing vaccination. This shows that, out issue gives chance to discuss moral and ethical development such as testing medicine on the animals. We can enhance our lesson plan by considering this point. I feel myself confident about support my

students' moral and ethical development but not very well. I think I will get this ability by the experiences." (FI_G7_FB, RP_2)

As it was mentioned in goals, although they could not finish their teaching in the planned time, they evaluated their goal accomplishment.

> "SI_G1_CU: In here, the important thing was helping students to learn, discuss the topic and comprehend the concepts. Therefore, we mostly focused on ensuring this. Although the time was not enough for our activities, our teaching was effective in this regard." (SI_VSRI_G1)

Therefore, these PSTs were aware of their SSI teaching in terms of contributing their students' reasoning, and literacy. Since they had clear goals in their minds in designing and implementing a technology integrated SSI lesson, they evaluated themselves to decide whether they reached those goals or not.

- Group Y: Evaluated their teaching only based on their effectiveness in time management

On the other hand, other PSTs could not evaluate their teaching. Most of them were not aware of their goals. Therefore, they could not evaluate whether they were effective or they evaluated their SSI teaching only based on their effectiveness in time and classroom management. Most of the time, they attributed their ineffectiveness to the time limitation. For example, as it can be seen in the following quotation, the PST criticized their goal achievement and blamed the limited time for their ineffectiveness. However, the PST did not elaborate how the time limit affected their effectiveness in reaching their objectives.

> "If the time was used efficiently and participation was good, it would be more reachable objectives, but we had difficulties in classroom management to progress SSI in class time.
>
> Due to use time inefficiently, we have troubled with communication in the web page environment. It caused to confusion in the class." (FI_G6_SET, RP_2)

Similarly, another PST in the second implementation again attributed their ineffectiveness in reaching their goals in terms of developing moral reasoning skills of students to the limited time. However, this group finished their teaching fifteen minutes earlier than the given time for their teaching performance.

> "Only the rule maker groups addressed moral reasoning. That is, they talked about the ethical issues. I wish we would have more time to inform other groups about the discussed issues in rule maker groups. Then, we would have chance to engage all of the students in moral reasoning." (SI_G7_HK, PTSI)

Moreover, since this PST focused on the completion of the tasks, he did not value different arguments proposed by students. This group used blog and included the summaries of the evidences in the blog to prevent wandering off the topic. Therefore, although the PST rated their technology usage effective, he perceived that it was a weakness for students to proposing different arguments as in the following quotation.

> "I think the summaries of the evidences were so effective in providing the learning environment that I intended. I did not want students to wander off the topic. However, I still do not understand how the rule makers produced the in-vitro argument. I thought that although the blog was effective in general, it had some weaknesses." (SI_G7_HK, PTSI)

Moreover, some of the PSTs evaluated their technology usage as effective due to its affordances for better time management.

> "We used time effectively thanks to Facebook. The reason of this was students are well equipped in Facebook usage." (FI_G8_AD, RP_2)

On the other hand, some of the PSTs could not decide whether they reached their aim or not. They generally thought that since they designed their lesson based on the curriculum objectives, they should have reached those objectives by completing the planned activities.

> "We considered developing students' reasoning skills in planning. I do not know but I assumed that we reached our goals, since we could implement all the activities in a way that we planned." (SI_G7_AY, PTSI)

> "Our teaching was congruent with our STSE objectives. We examined the curriculum and wrote STSE objectives from the curriculum. We designed our lesson according to these objectives. We did not evaluated our lesson that how much it was successful. However, we tried to address all of our objectives as much as possible." (SI_G2_DB, PTSI)

Most of the PSTs did not remember their goals. They frequently stated that it was not their responsibility to write the objectives of the lesson plan. Since another group member was responsible for deciding and writing the objectives, they were not sure whether they reached their objectives or not. Some of the PSTs even did not think about their effectiveness in reaching their goals.

> "I don't know if we reached our aim. I did not think on this." (SI_G7_AY, PTSI)

Therefore, these PSTs' evaluation of their teaching were so limited. They either could not evaluate themselves or their evaluation was not related to the goal accomplishment. Rather, they evaluated their teaching whether they could finish their teaching or not. They assumed that if they could implement the planned activities in the classroom, they accomplished their objectives automatically, because they planned their activities based on their objectives.

The differences between the percentages of PSTs in different groups for different implementations were similar with the differences in monitoring. Although 48% of the PSTs were categorized in Group X in terms of their evaluation in the second implementation, it was 27% in the first implementations. As PSTs stated in their interviews, this might be related to the difference in their confidence in content knowledge. Since more PSTs were confident in their content knowledge in the second implementation, the percentage of PSTs who evaluated their teaching effectively were also higher in the second implementation.

5.4.5. Postactive stage – Revising

PSTs offered different suggestions for revision of their teaching. While a group of PST (Group X) offered suggestions for revision to boost their SSI teaching based on their experiences, other PSTs (Group Y) only focused on better time management strategies in their revisions.

- Group X: Gave ideas about selecting more appropriate technologies to facilitate their instructional strategy or preparing more effective lesson plan

A group of PST (Group X) gave ideas about selecting more appropriate technologies to facilitate their instructional strategy or preparing more effective lesson plan. They suggested using different technologies to increase the effectiveness of the instructional strategy. For example, one of the PSTs from the second implementation stated that although using blog was effective in terms of providing a medium for sharing resources, it required the control of teachers while students were using it. Therefore, as in the following quotation, this PST thought that a revision should be done in their blog usage to prevent this.

> "I think using blog was not effective. First of all, students should be active in the lesson but when we use blog the teacher was more active beginning from entering the blog. Teacher needed to help students in understanding the content of the blog, where to reach the google document, how to fill the table etc. I want to find a better way to do this. I could not think that the teacher should be involved in the process that much. I prepared separate pages for each group; however, there was still confusion. Students could not decide where to write. Then, the teacher had to be involved too much. If I revise my lesson plan, I would think alternatives for blog and google document pages. I would search different more effective tool for sharing resource for evidences." (SI_G6_MCO, PTSI)

The groups that effectively integrate technology in SSI their teaching helped students be aware of the multiple perspectives in the SSI topic through different technological tools. Some of the PSTs realized that they were not effective in helping students be aware of other groups' arguments. Therefore, they suggested using technology more efficiently to ensure this.

> "We used the website that is OneDrive and we created four single file for each group. We said that each group has to access just their own file, in this way students have difficulty in seeing other groups' ideas. If we revise this part of lesson, we should use this website in a more efficient way by considering sharing students' ideas with each other." (FI_G6_RO, RP_2)

PSTs also realized the important role of technology in enabling effective monitoring of students' progress. One of the PSTs suggested using more interactive writing tools for idea sharing instead of Dropbox to be able to monitor students' progress systematically. This PST rated herself ineffective in monitoring. Based on the difficulties about monitoring she faced in teaching, she suggested using alternative technologies to compensate her deficiency in monitoring.

> "Also I want to use some interactive application instead of Dropbox because I want to see all actions of my students step by step." (FI_G5_DC, RP_2)

Similarly, some of the PSTs also realized the importance of technology in facilitating their instructional strategy by providing clear directions. Therefore, they suggested using blog in further SSI teaching lessons.

> "Maybe we can create blog about the alternative energy use. We can give the directions orderly in that blog page." (FI_G8_CAY, RP_2)

Some of the PSTs monitored students' responses to the implemented instructional technologies. Based on students' responses, PSTs assessed their technology usage whether they reached their aim or not. For example, some of the groups used videos to give students information about SSI as well as to catch their attention to the lesson. While showing videos in their teaching they realized that due to the excess amount of videos, students' attention was lost. Therefore, they suggested using more effective and short videos or using videos more interactively to keep students' attention.

> "Our technology integration in the first week was not much effective. I would remove one of the videos. Moreover, I would use videos more effectively by asking questions related to the video." (SI_G1_CU, PTSI)

> "I would prefer to use short interviews instead of videos for the first week's presentation. I would show videos through smartboard and write notes on it while watching. For example, if a student says something about the video I would stop and write on it. Then, it would be more interactive and effective." (SI_G1_AO, PTSI)

One of the PSTs got feedback from her friends about their group's presentation and learned that their Prezi presentation was difficult to follow. Based on this feedback, she suggested using other alternative presentation tools.

> "As far as I heard from my friend, Prezi was a bit reeling. Since it continuously zoom in and zoom out, it is difficult to follow the presentation. Therefore, I would prefer using another presentation tool." (SI_G2_ET, PTSI)

Group X's suggestions for revision of their teaching were not only related to technology usage. They also suggested different revisions to increase their effectiveness in SSI teaching with different strategies. For example, PSTs learned that in SSI teaching, teacher is responsible for helping students be skeptical about the potentially biased information reached through technology. Therefore, they admired the necessity of providing students resources for evidences. Most of them did this in their teaching. The groups who did not provide resources for students also suggested doing so.

> "Teacher should be sure about the reliability of the sources s/he gives to the students. Because, while searching we saw many resources that do not reflect the reality. These resources should be selected carefully. Moreover, teacher should guide students in comprehending the necessity of using reliable resources. Therefore, I would emphasize on this more in my teaching." (SI_G6_OU, PTSI)

PSTs also realized the need for providing students understandable evidences to increase the quality of their argumentation.

> "Based on my observations of all groups' teaching, although you provide evidences to the students, they tended to close those and open Google search page. For this reason, I think that the evidences should be so simple and clear. Giving them articles is not much appropriate. Because using Google for search is so easy. Therefore, they tended to search from Google. Therefore, the evidences should be as simpler as possible." (SI_G4_KD, PTSI)

Another suggestion for revision was about the specificity of the selected SSI topic. Since some of the groups selected more general SSI topics, they had difficulty in guiding argumentation. Therefore, they suggested using more specific SI topic as in the following quotations.

> "We could change our lesson plan to choose one alternative energy source because it can be easier to manage." (FI_G8_AD, RP_2)

> "We could choose the advantages and disadvantages of a more specific alternative energy. For example, we could say that we will discuss the HES's advantages and disadvantages." (FI_G8_CAY, RP_2)

Some of the PSTs realized their deficiency in monitoring students' progress and assessing their understanding, so they suggested ways to do this.

"FI _G6_BE: After explaining our case, we would have monitored students' reactions. We would ask them what was included in the case. We would assess whether they understood or not.

FI_G6_RO: Yes, we would get feedback from students about our teaching to learn whether they understood or not." (FI_VSRI_G6)

"For example, when a group expresses their ideas, we would listen well and say that your friends think so, what about you, are you agree or disagree with your friends' opinions." (FI_G2_SUA, RP_2)

Some of the PSTs suggested preparing an effective, functional lesson plan before teaching SSI through technology. These PSTs realized that preparing detailed lesson plans helped them gain confidence in implementing; therefore, they suggested preparing an effective lesson plan as in the following quotation.

"I would not make changes in the lesson flow. However, I would like to extend the explanations about possible problems and solutions to those problems. I realized that we did not write the most possible problems in our lesson plan. For example, we did not think about the problems we can encounter during grouping. Therefore, I panicked. We wrote there the problems about internet outage or electricity shortage. However, we should have included more detail about the possible problems we can face during teaching or the directions that should be given to students. I would prepare more detailed lesson plan in that sense". (SI_G2_DB, PTSI)

One of the PSTs who rated herself poor in monitoring also suggested using more detailed lesson plan to be able to monitor their students better.

"However, we need to improve ourselves in monitoring the class especially while students are discussing the issue. In order to teach the issue effectively by following lesson plan, we need to prepare very well before teaching." (FI_G1_AK, RP_2)

Moreover, PSTs suggested being well-prepared in terms of their content knowledge or technology knowledge. They stated that in order to integrate a technological tool, the teacher should be knowledgeable about the tool to overcome the problems and guide students effectively to use it in an intended way.

"The teacher should know technological tool very well, because they are supposed to teach their students well. We experienced that if the teacher does not know the technological tool herself, it is very probable that she will face with unexpected problems. I saw even in OneDrive usage of

> students. The students entered pages that I have ever seen. I had to guide them effectively; therefore, my technological knowledge was important." (SI_G2_DB, PTSI)

Similarly, PSTs suggested being well prepared in terms of the SSI topic, based on their experiences in their teaching.

> "The teacher should be well prepared to the SSI topic in order to teach it. The teacher should answer any student question. Therefore, I would suggest teachers to be well qualified in the topic." (SI_G7_OU, PTSI)

Lastly, PSTs suggested revisions for assessment. They suggested making use of technological tools to do more creative assessments.

> "I would add new technological tools to my lesson plan. Because I would like to assess students' prior knowledge. I would also want to assess students at the end of the lesson again. I would apply something like an online quiz." (SI_G3_AFE, PTSI)

The PST, whose quotation was given above, rated herself poor in terms of assessing. Therefore, they suggested revision based on her need for more effective assessment. On the other hand, one of the PSTs saw the positive effect of the online assessment tool on their teaching and the need for a short review in others groups' teachings. Therefore, he suggested using a short online quiz for a review of previous lesson.

> "I would suggest using especially Kahoot. Actually, I would suggest teachers to review the lesson with an enjoyable tool like Kahoot. I observed in the teaching of the next group that the teachers could not get answers from the students when they asked questions about the previous lesson. This caused the lesson being stucked. Moreover, this situation decreases the reputation of the teacher. Therefore, there should definitely be something to make this review process enjoyable." (SI_G7_MCO, PTSI)

Therefore, these PSTs were aware of their strengths and weaknesses in SSI teaching and offered suggestions based on this. Their aim in these revision suggestions were to increase the quality of their SSI teaching.

- Group Y: Gave ideas for better time management

Group Y, on the other hand, gave ideas for better time management for revising. They could not refer to their strengths and weaknesses in making revision. They only focused on better time management strategies. Moreover, they suggested not using the technological tool that they faced with technical problems, instead of offering more effective alternative tools or preventive solutions to the problems.

> "Smartboard caused difficulty and time consumption. Thus, it could be extract from the lesson plan." (FI_G1_SKO, RP_2)

Moreover, although some of them suggested using different technological tools, the underlying reason was to manage time more efficiently, instead of facilitating SSI reasoning.

> "We would prepare a sheet and add in Dropbox. Students could reach them with the group computer and they could write their ideas and upload them to Dropbox again. Therefore, teaching process could be easier and time could be also controlled." (FI_G2_SK, RP_2)

There was a considerable difference in metacognitive thoughts of PSTs in different implementation in terms of revising. In the first implementation, only 35% of PSTs offered meaningful revision suggestions. On the other hand, 89% of the PSTs in the second implementation gave ideas about selecting more appropriate technologies to facilitate their instructional strategy or preparing more effective lesson plan based on their experiences in teaching. This difference might be explained with the differences in the quality of the groups' teachings in different implementations. Since the groups in the second implementation showed better performances in terms of technology integration and implementation of argumentation, the PSTs in the second implementation had more chance to see effective examples. Therefore, they suggested revisions that were more appropriate. On the other hand, in the first implementation, although PSTs observed themselves and saw their weaknesses in SSI teaching with technology, they could not suggest revisions except for their time management problems due to the lack of effective examples.

5.5. Knowledge of PSTs for Effective SSI Teaching with Technology and the Patterns of their Metacognitive Thoughts

PSTs' patterns of their metacognitive thoughts and their TPACK for effective SSI teaching scores, as retrieved from the group lesson plans, group teaching performances and individual lesson plans, were provided in Table 23 and Table 24. As it was mentioned above, none of these PSTs' metacognitive thoughts can be considered as superior to others. However, their focus of their thoughts showed differences. These differences were found to be related to the differences in their TPACK for effective SSI teaching scores. Therefore, the relationship between their metacognition and TPACK development for effective SSI teaching was tried to figure out.

When PTSs' metacognitive patterns were investigated, different patterns were figured out. Therefore, while their metacognitive thoughts were categorized in Group X for one metacognitive component, their thoughts might be categorized in Group Y for other component. Among 45 PSTs, 8 of them (3 from FI and 5 from SI) were categorized in Group X in terms of each metacognitive component. Moreover, although her metacognitive knowledge of content was categorized in Group Y, SI_G7_IT was categorized in Group X for the remaining metacognitive components. Therefore, the differences in her individual lesson plan scores showed similarity to the differences of the scores of 8 PSTs who were categorized in Group X in terms of each metacognitive component.

On the other hand, 8 (7 from FI and 1 from SI) PSTs were categorized in Group Y in terms of each of the metacognitive components. Moreover, although their knowledge of content were categorized in Group X, FI_G8_ME and FI_G8_AD were categorized in Goup Y for the remaining metacognitive components. The differences in these PSTs' individual lesson plan scores also showed the same pattern with the PSTs, whose metacognitive thoughts were categorized in Group Y in terms of each component.

When the TPACK for effective SSI teaching of the PSTs, whose metacognitive thoughts were categorized as X for each component, were examined, it can be said that their knowledge of instructional strategies and representations for effectice SSI teaching with technology (KoIS) scores were different if we compare their TPACK for effective SSI teaching scores in group lesson plans and individual lesson plans. Their KoIS scores in the individual lesson plans either the same with or higher than their KoIS scores of group lesson plans. The only exceptional PST was one of the PSTs from the second implementation whose pseudonym was SI_G6_MCO. Although the KoIS score of their group lesson plan was 3.17, this PST's KoIS score was 2.67 in individual lesson plan. The reason might be related to the demographic characteristics of this PST. This PST stated that, he did not take the methods course yet. He stated that although he did not take the method course, he learned how to implement argumentation in this course. However, since teaching the theoretical knowledge about argumentation was not in the scope of the re-designed course, his theoretical knowledge might not be developed well, although he gained experience in implementing and increased his practical knowledge.

On the other hand, the KoIS scores of PSTs, whose metacognitive thoughts were categorized as Group Y for each component, were different in the individual lesson plans and the group lesson plans. Their KoIS scores in individual lesson plans were either lower than or the same with the KoIS scores of their group lesson plans. The only exceptional PST was FI_G2_AK. This PST rated her pedagogical knowledge and SSI knowledge as poor due to the difficulties she faced with during their teaching performance. She frequently stated that although she and her group members read a lot about their SSI topic and argumentation strategy, she was not so confident. She thought that they had difficulty in managing argumentation in their teaching. Therefore, although she rated her knowledge as poor, she might underestimate her knowledge.

Table 23.

Metacognitive Patterns and TPACK for Effective SSI Teaching Rubric Scores of PSTs in the First Implementation

Participants	Metacognitive Components							GLP Rubric Scores				Teaching Rubric Scores				ILP Rubric Scores			
	KC	KP	P	M	Rg	E	Rv	KoC	KoIS	KSU	KoA	KoC	KoIS	KSU	KoA	KoC	KoIS	KSU	KoA
FI_G1_AG	Y	Y	Y	Y	Y	Y	Y	4.00	2.17	4.00	1.50	3.00	2.17	3.00	1.50	3.00	2.17	2.00	1.50
FI_G1_BK	X	Y	Y	Y	Y	Y	X	4.00	2.17	4.00	1.50	3.00	2.17	3.00	1.50	4.00	2.83	4.00	2.00
FI_G1_MK	X	X	Y	Y	Y	Y	Y	4.00	2.17	4.00	1.50	3.00	2.17	3.00	1.50	3.00	3.00	4.00	2.50
FI_G1_SKO	Y	Y	Y	Y	Y	Y	Y	4.00	2.17	4.00	1.50	3.00	2.17	3.00	1.50	4.00	2.17	3.00	1.50
FI_G2_AK	Y	Y	Y	Y	Y	Y	Y	3.00	1.83	3.00	2.50	2.00	1.83	3.00	2.00	3.00	2.83	3.00	3.00
FI_G2_BU	Y	X	X	Y	Y	Y	Y	3.00	1.83	3.00	2.50	2.00	1.83	3.00	2.00	3.00	1.50	2.00	2.50
FI_G2_MBT	Y	Y	Y	Y	Y	Y	X	3.00	1.83	3.00	2.50	2.00	1.83	3.00	2.00	3.00	2.17	3.00	2.50
FI_G2_SK	Y	Y	Y	Y	Y	Y	Y	3.00	1.83	3.00	2.50	2.00	1.83	3.00	2.00	3.00	1.67	3.00	1.50
FI_G2_SUA	Y	Y	Y	Y	Y	Y	Y	3.00	1.83	3.00	2.50	2.00	1.83	3.00	2.00	3.00	1.50	3.00	2.50
FI_G5_DC	X	X	X	Y	X	Y	X	4.00	2.67	4.00	2.50	4.00	3.00	4.00	2.50	3.00	1.67	3.00	1.50
FI_G5_RD	X	X	X	X	X	X	X	4.00	2.67	4.00	2.50	4.00	3.00	4.00	2.50	3.00	2.67	4.00	2.00
FI_G5_SA	Y	Y	Y	Y	Y	Y	Y	4.00	2.67	4.00	2.50	4.00	3.00	4.00	2.50	3.00	1.67	2.00	1.50
FI_G6_BE	Y	X	X	Y	Y	Y	Y	4.00	2.83	4.00	1.50	3.00	3.00	3.00	2.50	3.00	2.83	3.00	2.50
FI_G6_BY	X	X	Y	X	X	X	Y	4.00	2.83	4.00	1.50	3.00	3.00	3.00	2.50	4.00	2.83	4.00	1.50
FI_G6_RO	Y	X	X	Y	X	Y	X	4.00	2.83	4.00	1.50	3.00	3.00	3.00	2.50	4.00	2.50	4.00	3.00
FI_G6_SET	X	X	X	Y	X	Y	X	4.00	2.83	4.00	1.50	3.00	3.00	3.00	2.50	3.00	2.50	3.00	2.50
FI_G7_BB	Y	X	X	X	X	X	Y	4.00	3.50	3.00	4.00	4.00	3.80	4.00	4.00	3.00	2.33	2.00	3.50
FI_G7_CA	Y	Y	Y	Y	Y	Y	Y	4.00	3.50	3.00	4.00	4.00	3.80	4.00	4.00	3.00	2.67	2.00	3.00
FI_G7_DB	Y	X	X	Y	X	Y	Y	4.00	3.50	3.00	4.00	4.00	3.80	4.00	4.00	2.00	1.67	2.00	1.50
FI_G7_FB	X	X	X	X	X	X	X	4.00	3.50	3.00	4.00	4.00	3.80	4.00	4.00	4.00	3.50	3.00	2.50
FI_G7_OK	X	X	X	X	X	X	Y	4.00	3.50	3.00	4.00	4.00	3.80	4.00	4.00	3.00	2.50	3.00	2.50
FI_G8_AD	X	Y	Y	Y	Y	Y	Y	4.00	2.83	3.00	2.50	3.00	2.80	3.00	2.50	3.00	2.67	3.00	1.50
FI_G8_CAY	Y	X	X	X	X	X	X	4.00	2.83	3.00	2.50	3.00	2.80	3.00	2.50	3.00	2.00	2.00	1.50
FI_G8_EY	X	X	X	X	X	X	X	4.00	2.83	3.00	2.50	3.00	2.80	3.00	2.50	4.00	2.83	3.00	2.00
FI_G8_ME	X	Y	Y	Y	Y	Y	Y	4.00	2.83	3.00	2.50	3.00	2.80	3.00	2.50	3.00	2.67	2.00	1.50

Table 24.

Metacognitive Patterns and TPACK for Effective SSI Teaching Rubric Scores of PSTs in the Second Implementation

Participants	Metacognitive Components							GLP Rubric Scores				Teaching Rubric Scores				ILP Rubric Scores			
	KC	KP	P	M	Rg	E	Rv	KoC	KoIS	KSU	KoA	KoC	KoIS	KSU	KoA	KoC	KoIS	KSU	KoA
SI_G1_DCI	X	X	X	X	X	X	X	4.00	3.00	4.00	3.50	4.00	3.17	3.00	3.00	4.00	3.17	3.00	3.00
SI_G1_EC	Y	Y	Y	Y	Y	Y	Y	4.00	3.00	4.00	3.50	4.00	3.17	3.00	3.00	3.00	2.33	3.00	2.50
SI_G1_CU	X	X	X	X	X	X	X	4.00	3.00	4.00	3.50	4.00	3.17	3.00	3.00	4.00	3.50	4.00	2.50
SI_G1_AO	Y	X	Y	X	X	X	X	4.00	3.00	4.00	3.50	4.00	3.17	3.00	3.00	4.00	3.00	4.00	3.50
SI_G2_DB	Y	X	X	Y	Y	X	X	3.00	3.00	3.00	2.50	3.00	3.00	3.00	3.00	4.00	2.67	4.00	1.50
SI_G2_ET	Y	X	X	Y	Y	Y	X	3.00	3.00	3.00	2.50	3.00	3.00	3.00	3.00	4.00	3.17	4.00	3.00
SI_G3_BB	X	Y	X	X	Y	X	X	3.00	2.33	2.00	2.50	3.00	2.50	2.00	2.50	3.00	2.17	3.00	2.50
SI_G3_FK	X	Y	X	Y	Y	Y	X	3.00	2.33	2.00	2.50	3.00	2.50	2.00	2.50	4.00	2.67	3.00	2.50
SI_G3_AFE	Y	Y	X	X	X	Y	X	3.00	2.33	2.00	2.50	3.00	2.50	2.00	2.50	3.00	2.50	2.00	1.50
SI_G4_KD	Y	Y	X	Y	Y	Y	X	3.00	3.00	3.00	3.00	2.00	2.33	2.00	2.50	3.00	2.50	3.00	2.50
SI_G5_NFO	Y	Y	X	Y	X	Y	X	3.00	3.17	3.00	3.00	3.00	3.50	3.00	3.00	4.00	3.00	3.00	3.00
SI_G5_BKS	X	Y	X	X	Y	Y	X	3.00	3.17	3.00	3.00	3.00	3.50	3.00	3.00	3.00	2.67	2.00	2.50
SI_G6_MCO	X	X	X	X	X	X	X	3.00	3.17	3.00	3.00	4.00	3.50	3.00	3.00	4.00	2.67	3.00	3.50
SI_G6_OU	X	X	X	X	X	X	X	3.00	3.17	3.00	3.00	4.00	3.50	3.00	3.00	4.00	3.67	4.00	3.00
SI_G6_DT	X	X	X	X	X	X	X	3.00	3.17	3.00	3.00	4.00	3.50	3.00	3.00	3.00	3.67	4.00	2.50
SI_G7_MK	X	Y	X	X	X	X	Y	3.00	2.67	3.00	2.50	3.00	3.17	3.00	2.50	3.00	2.50	3.00	2.50
SI_G7_HK	Y	Y	Y	Y	Y	Y	X	3.00	2.67	3.00	2.50	3.00	3.17	3.00	2.50	3.00	2.83	3.00	2.50
SI_G7_AY	X	Y	X	Y	Y	Y	X	3.00	2.67	3.00	2.50	3.00	3.17	3.00	2.50	2.00	2.50	3.00	2.50
SI_G7_IT	Y	X	X	X	X	X	X	3.00	2.67	3.00	2.50	3.00	3.17	3.00	2.50	4.00	2.83	4.00	3.00

Note. GLP=Group Lesson Plans, ILP=Individual Lesson Plans, KC=Knowledge of Content, KP=Knowledge of Pedagogy, P=Planning, M=Monitoring, Rg=Regulating, E=Evaluating, Rv=Revising, KoC=Knowledge of Curriculum, KoIS=Knowledge of Instructional Strategies, KSU=Knowledge of Student Understanding, KoA=Knowledge of Assessment

Moreover, other reason might be that since she thought that her knowledge was deficient, she might also put more effort for her individual lesson plan. This PST's knowledge of assessment score as retrieved from her individual lesson plan also was higher than the group lesson plan. Similarly, since she mentioned frequently about their difficulty in managing and monitoring students during argumentation, as it can be seen from the quotations given in previous sections, she might think more about the ways to monitor and assess students' progress. Therefore, her knowledge of assessment showed difference in the individual lesson plan.

PSTs' knowledge of curriculum and curricular materials that integrate technology in effective SSI teaching (KoC) showed a similar pattern according to their metacognitive thoughts. KoC scores of PSTs, whose metacognitive thoughts were categorized as Group X for each component, were higher in their individual lesson plans as compared to their groups' lesson plan scores. On the other hand, KoC scores of PSTs, whose metacognitive thoughts were categorized as Group Y for each component, were lower in their individual lesson plans as compared to their groups' lesson plan scores. Since the PSTs in the Group X focused more on the integration of technology to reach their curricular goals. Moreover, these PSTs' goals were to develop their students' SSI reasoning skills, scientific and technological literacy. In line with this goal, they effectively examined the curriculum and selected the proper curricular objectives and tried to achieve those objectives. Therefore, their curriculum knowledge was high in their individual lesson plans.

However, PSTs in Group Y aimed to integrate technology into their SSI teaching without a clear rational for increasing the quality of their teaching. While monitoring and evaluating their teaching, these PSTs mostly focused on the completion of the tasks in the planned time and monitored students engagement in the activities without evaluating their goal accomplishment. Therefore, they had difficulty in determining related objectives for their SSI teaching in their individual lesson plans.

Similar pattern was also seen about the knowledge of students' understanding, thinking and learning in SSI teaching (KSU). All of the PSTs, whose metacognitive thoughts were categorized as Group X for each component, got higher scores of KSU in their individual lesson plans as compared to their group lesson plans. On the other hand, KSU scores of PSTs, whose metacognitive thoughts were categorized as Group Y for each component, were lower in their individual lesson plans as compared to their groups' lesson plan scores. The PSTs in this group were able to monitor their teaching and the effect of their teaching on students' development. Therefore, they were confident in addressing students' prior knowledge, misconceptions that can interfere with their SSI reasoning. Moreover, they also effectively addressed students' moral and ethical reasoning. Therefore, they critically analyzed students' developmental level that can be influential in their reasoning.

The pattern mentioned above for KoIS, KoC and KSU could not be seen for knowledge of assessment with technology in effective SSI teaching (KoA). In both group, PSTs' KoA scores either decreased or remained the same in their lesson individual lesson plans. Although especially, PSTs in the second implementation observed effective assessment practices through technology, they did not integrate technology into their assessment strategies in their individual lesson plans.

PSTs' metacognitive thoughts about revising component have found to be influential in the quality of their individual lesson plans. Although PSTs' thoughts were categorized as Group Y in other components, if their metacognitive thoughts about revising were categorized as Group X, their individual lesson plan scores were higher as compared to the group lesson plans.

For example, metacognitive thoughts of FI_G1_BK were categorized as Group Y in each component except knowledge of content and revising. When the LEPR-TIST scores obtained from her individual lesson plan was examined, it can be seen that the scores of two TPACK dimensions were higher in her individual lesson plan. Since the KoC and KSU scores of their group lesson plans were rated at the highest level, her KoC and KSU scores were also 4.00 in individual lesson plan. This can be interpreted that since this PST was aware of her knowledge about SSI and had an idea about how to revise her lesson plan to teach SSI topics better, she was able to revise her thoughts and reflected those revision ideas on her individual lesson plan.

Conversely, metacognitive thoughts of FI_G7_BB were categorized as Group X in each component except knowledge of content and revising. She was not confident in her SSI knowledge and had no clear idea about how to revise her teaching for better SSI teaching. Therefore, her scores for each TPACK dimension were lower in her individual lesson plan.

In some other examples, metacognitive thoughts of FI_G2_MBT and SI_G7_HK were categorized as Group Y in terms of each metacognitive component except revising. Those PSTs' KoIS scores were found to be higher in their individual lesson plans than their group lesson plans. Moreover, although KoC, KSU and KoA scores of most of the PSTs categorized in Goup Y for each metacognitive components were lower in their lesson plans, this was not the case in the individual lesson plans of FI_G2_MBT and SI_G7_HK.

Conversely, individual lesson plan rubric scores of FI_G7_OK were lower for each TPACK dimensions as compared to the group lesson plans. This PSTs' metacognitive thoughts were categorized in Group X for each component except revising. Although she were aware of her strengths and weaknesses and focused on their goal accomplishment in her monitoring and evaluating, she could not focus on her weaknesses in revision suggestions. Instead, she provided suggestions for better time management. Therefore, her rubric scores were lower in her individual lesson plan for each TPACK dimension as compared to their group lesson plan.

In addition to individuals' development of effective SSI teaching practices with technology, metacognitive thoughts of the group members were also found to be related to their group performance. Metacognitive thoughts of PSTs in interactive stage were related to their thoughts during teaching. It includes their monitoring of their teaching and regulation of their teaching according to their monitoring. Therefore, PSTs' metacognitive thoughts during teaching were assumed to be influential in their teaching performance. Therefore, we examined the relationship between metacognitive thoughts during teaching and their teaching performances as retrieved from Teaching Performance Evaluation Rubric for Technology Integration into SSI Teaching (TPER-TIST). If most of the group members' monitoring and regulating were categorized as Group Y, their teaching performance scores were found as lower than their group lesson plans. For example, when the scores of the first group of first implementation were examined, it can be observed that their KoC and

KSU scores were lower in their teaching rubric scores. Similarly, KoC and KoA scores of the second group of the first implementation were also lower in teaching performance. The members of these groups focused more on the completion of the activities instead of development in students' reasoning skills and scientific and technological literacy. Morover, they hesitated to make necessary regulations when they observed problems in implementation of their lesson plans. Therefore, their teaching performance scores were lower than their group lesson plan scores.

On the other hand, if majority of the group members' metacognitive thoughts were categorized in Group X in terms of monitoring and regulation, their teaching performance scores were either the same with or higher than their group lesson plan scores. For example, when the scores of the seventh group of the first implementation were examined, it can be seen that their KoC and KSU scores were higher in their teaching performance scores. Since most of the group members' metacognitive thoughts in monitoring and regulating were found to be in Group X, their thoughts influenced the quality of the group's performance. Therefore, it can be said that engaging more productive metacognitive thought during teaching increased the quality of the implementation of the lesson plans.

In addition to these general patterns mentioned above, to understand the relationship between the metacognitive thought and TPACK of PSTs' for effective SSI teaching well, the individual lesson plans of the PSTs whose metacognitive thoughts were grouped in either Group X or Group Y for each component were examined in detail. These PSTs' TPACK for effective SSI teaching were compared based on the Lesson Plan Evaluation Rubric for Technology Integration into SSI Teaching (LPER-TIST) scores of their individual lesson plans. When their mean scores for each criteria of the rubric were compared, it can be said that, the scores of Group X for each criteria were greater than the scores of Group Y. Moreover, PSTs categorized as Group X in the second implementation mainly got higher scores than the PSTs in the first implementation as it can be seen in Table 25. As it was mentioned in 3.5.1, there were ten criteria in LEPR-TIST. Each criteria had four levels with different definitions for each level. In Table 25, the frequencies of PSTs who were rated in each level of each criterion was given.

Table 25

Descriptive of LPER-TIST Results of PSTs for Individual Lesson Plans with Different Metacognitive Thoughts

Criteria	Levels	Group X				Group Y			
		FI		SI		FI		SI	
		n	x̄	n	x̄	n	x̄	n	x̄
1	1	0	2.00	0	3.40	0	2.14	0	2.00
	2	3		1		6		1	
	3	0		1		1		0	
	4	0		3		0		0	
2	1	0	2.33	0	3.20	0	2.14	0	2.00
	2	2		1		6		1	
	3	1		2		1		0	
	4	0		2		0		0	
3	1	0	2.67	0	3.60	2	2.50	0	3.00
	2	2		0		2		0	
	3	0		2		2		1	
	4	1		3		1		0	
4	1	0	2.67	0	3.40	4	2.29	0	2.00
	2	2		1		2		1	
	3	0		1		1		0	
	4	1		3		0		0	
5	1	0	2.67	0	2.20	3	1.85	0	2.00
	2	1		4		2		1	
	3	2		1		2		0	
	4	0		0		0		0	
6	1	0	3.33	0	3.60	0	2.57	0	3.00
	2	0		0		3		0	
	3	2		2		4		1	
	4	1		3		0		0	
7	1	0	3.67	0	3.80	0	3.57	0	3.00
	2	0		0		0		0	
	3	1		1		7		1	
	4	2		4		1		0	
8	1	0	2.33	0	2.80	0	2.29	0	3.00
	2	2		1		5		0	
	3	1		4		2		1	
	4	0		0		0		0	
9	1	0	2.00	0	3.00	4	1.86	0	2.00
	2	3		1		0		1	
	3	0		3		3		0	
	4	0		1		0		0	
10	1	0	3.33	0	3.80	0	2.71	0	3.00
	2	0		0		3		0	
	3	2		1		3		1	
	4	1		4		1		0	

Note. LPER-TIST=Lesson Plan Evaluation Rubric for Technology Integration into SSI Teaching, FI=First Implementation, SI=Second Implementation

When we looked at the scores PSTs got for the first criterion of the LPER-TIST, we realized that the highest scores were taken by the PSTs categorized in Group X in the second implementation. It can be implied based on this result that those PSTs were better in providing solutions to the technological problems or providing alternative technology to compensate, in case of big obstacle. These PSTs were aware of the constraints and affordances of the technologies that they planned to be used. Therefore, they could easily predict the possible problems and provided alternative solutions to those problems in their lesson plan. Moreover, since they were confident in their pedagogy knowledge, they were also aware of the technologies that can help them increase the quality of the implementation of their instructional strategy. When the metacognitive thinking of Group X was examined, it was found that these PSTs were confident in their knowledge about the benefits of the selected technology in terms of facilitating their instructional strategy. For example, they stated that they selected a collaborative writing tool, because they were aware of the possibilities of that tool in contributing to argumentation.

The result for the second criterion of the rubric was the same that the PSTs categorized as Group X in the second implementation got the highest scores. The second criterion was related to providing clear instructions to students about technology usage in SSI teaching.. They had a clear goal in using the technology and were aware of the possibilities of the technology in facilitating SSI teaching. Therefore, they knew the ways to help their students to benefit from the utilities of technology in learning SSI and engaging SSI reasoning at upmost level. For this reason, they did not have difficulty in providing necessary guidance to the students about technology usage.

The third criterion of the rubric was related to guiding group work with technology in SSI teaching and learning. Again, PSTs of Group X in the second implementation got the highest score in this criterion. Most of these PSTs' lesson plans were rated in the highest level. This indicated that the technology-integrated activities planned by these PSTs required group works and the technology facilitated groups' work by providing necessary guidance, by allowing the communication among all of the groups with different perspectives. The better quality of these PSTs' lesson plans might be related to their metacognitive knowledge of content, pedagogy. These PSTs were confident in their pedagogy knowledge and content knowledge. Since they had awareness about their SSI knowledge, they were effective in determining the arguments of different perspectives. Therefore, they arranged groups to discuss these arguments from multiple perspectives. Moreover, since they were aware of their argumentation knowledge, they had confidence in guiding an argumentative discussion among the groups and they had confidence in facilitating these discussions through technology. Therefore, they effectively planned group works for engaging students in SSI reasoning and took advantage of technology to facilitate these processes.

Similarly, beliefs of PSTs in Group X were also influential in their effectiveness in guiding group work with technology in SSI teaching and learning. These PSTs viewed the role of students as active participants who were responsible to think, reason, discover and communicate. Therefore, they were effective in creating such an environment to trigger students' active knowledge construction and reasoning through the communication in and among the groups.

Concerning the fourth criterion, Group X got higher scores and the PSTs of Group X in the second implementation were better than the PSTs in the first implementation. This criterion was related to the PSTs' ability to use variety of activity types to teach concepts and phenomena inherent in the selected SSI topic with technology. The PSTs in Group X were effective in selecting technologies for different activity types. They selected technologies to activate students' prior knowledge, to visualize the concepts and phenomena to increase the understandability, to facilitate the communication between the students, and to assess their students' comprehension and skills. Since these PSTs viewed the technology as more than an auxiliary tool to present the knowledge as an alternative way, they planned to use technology for variety of purposes. These PSTs planned to use presentation tools, multimedia tools or polls to activate their students' prior knowledge. Moreover, they used multiple visual tools like images, videos or animations to help students comprehend the topic effectively. Furthermore, as it was mentioned above, these PSTs ensured the communication among the students through different communication tools like blogs, online discussion groups or collaborative writing tools. They also took advantage of the technology to get data about students' progress through different assessment tools.

Group X also viewed the teacher as creative user of technology in reaching their goals. Therefore, they could effectively repurpose the available technological tools to reach their goals. Since their overall aim was to engage students in SSI reasoning, they took advantage of the technology to reach this end.

For the fifth criterion, Group X PSTs in the first implementation got the highest scores. This criteria was related to skepticism that is one of the aspects of SSI reasoning. Sadler et al. (2007) mentioned skepticism as one of the aspects of SSI reasoning and argued that "advanced practice should include the ability to demonstrate skepticism in the face of potentially biased information and strategies to make well grounded decisions regarding the selection of information sources" (p.375). Therefore, PSTs helping students to be aware of the potentially biased information and making decisions considering this criterion in selecting the information sources were rated with higher scores. Since the PSTs in Group X were confident in their knowledge about the SSI topic and knowledge about how to teach SSI topics, they considered the aspects of SSI reasoning in their lesson plans.

On the other hand, the PSTs in Group Y were rated either in level 2 or level 1. The PTSs rated in the level 1 were not even skeptical about the potentially biased information themselves. Therefore, they did not provide reliable sources to the students or did not warn students to reach the reliable information. The PSTs rated in the level 2 were skeptical and provided students an opportunity to reach unbiased information resources; however, they were not aware of the need for helping their students develop understanding of this. Therefore, the PSTs rated in level 2 gave unbiased information ready to student without any warning about potentially biased information that can be reached through technology. The PSTs in Group Y were not sure about their pedagogical knowledge to teach SSI. Moreover, they were not aware of the possibilities of technology in helping them to engage their students in SSI reasoning effectively. Therefore, they could not plan to help their students in developing skepticism.

The sixth criterion was related to the effectiveness of PSTs in facilitating SSI argumentation through technology. Researchers in the area of argumentation underlined the importance of encouraging students to consider alternative perspectives challenging their own ideas. Similarly, Sadler et al. (2007) suggested involving students in the practices that require analyzing the SSI and the potential solutions to the SSI from multiple perspectives including the challenges to their own positions. Therefore, in this study, we rated PSTs at the lowest level if they only benefited from the technology to engage students in the lesson by attracting them. Besides this, if PSTs effectively guided their students to analyze their SSI and collect evidences to produce justification for their own claim, they were rated in the second level. Beyond these, if PSTs effectively guided their students to be aware of counter-arguments related to their claims, they were rated in the third level. Lastly, we rated PSTs at the highest level, if they effectively encouraged their students to do rebuttal to justify their claim in response to the counter-arguments without a fear of personal statements through technology. PSTs in the Group X were mostly rated in the third and fourth level. Group X PSTs' beliefs and goals might be influential in their effectiveness in facilitating argumentation with technology in SSI teaching and learning. These PSTs viewed the role of technology important in facilitating inquiry rather than viewing technology as an auxiliary tool in attracting students. Therefore, their technology usage had central role in facilitating SSI reasoning.

For the seventh criterion, PSTs were rated about their effectiveness in matching technology to the learning objectives of the science curriculum. Since PSTs need to have knowledge about curriculum and curricular goals in order to integrate technology into SSI teaching effectively, their lesson plans were rated in terms of integrating technology to address learning objectives from different learning areas defined in the science curriculum. According to their statements, the PSTs of Group X wanted to help students construct their own meaning, develop reasoning skills, and scientific and technological literacy in their technology integrated SSI teaching lessons. Therefore, in their individual lesson plans, they included objectives from knowledge, skills and science-technology-society-environment learning areas. In order to reach those objectives, these PSTs benefited from technology to present the scientific concepts related to their SSI topic, to develop students' reasoning skills and to help them comprehend the interrelationship between science technology society and environment.

With regard to the eighth criterion, we rated PTSs' lesson plans in terms of the strategies mentioned to monitor and manage students' progress on technology usage during SSI teaching and learning. The scores of the groups were similar in both implementations. This rubric criterion aimed to evaluate PSTs ability to monitor their students' technology usage skills. There were not any PSTs rated at the highest level in which PSTs were expected to select technological tools that allow teachers to quickly assess the progress of students and determine whether individualized or class-wide interventions are necessary. The PSTs' lesson plans were rated at either the second or the third level. In the second level, the PSTs were expected to state only simple strategies that are not useful to monitor all students' progress in technology usage (e.g. walking around in the classroom to see students' progress, asking students whether they are on task or not). If PSTs stated strategies to monitor all students' progress with the help of a technological tool but could not manage their progress, they were rated at the third level.

These skills were related to the PSTs' metacognitive thoughts in interactive stage. The PSTs in Group X rated themselves effective in observing, listening to and pursuing students' ideas. In their monitoring, they focused on students' understanding and quality of argumentation as well as technology usage skills. Therefore, their lesson plans were rated mostly at the third level. Similarly, the PSTs in the Group Y monitored their students' participation during teaching and focused on students' completion of tasks or ability to operate technological tools. Therefore, they also included strategies to monitor students' progress in technology usage in their lesson plans. However, since the PSTs in Group Y were not confident in regulating, they could not find strategies that can be rated at the highest level including managing students' progress beyond monitoring.

Concerning the ninth criterion, which was about PSTs' assessment of students' understanding, the lesson plans of PSTs in Group X were rated higher compared to the lesson plans of PSTs in Group Y. The PSTs in the Group X of second implementation got the highest rating scores in this criterion. They were effective in selecting technological tool to assess students' SSI learning for diagnostic, formative or summative purposes. Since the PSTs in Group X were clear about their goals, confident about their content, pedagogy knowledge in reaching these goals and their skills to evaluate their effectiveness in reaching these goals, they effectively selected technological tools for the purpose of assessment.

The last criterion was about considering students' characteristics in planning technology-integrated activities to engage students in scientific and social inquiry. Since students' background knowledge, misconceptions, cognitive and moral development level may affect their engagement in scientific and social inquiry, PSTs' lesson plans were rated higher based on the extend of considering these characteristics. PSTs in the Group X were better in this criterion. They stated the students' characteristics and their effects on students' learning.

5.6. Summary

In this chapter, the patterns of PSTs' metacognitive thoughts were revealed. The overarching metacognitive components of knowledge, beliefs and goals were figured out based on the commentaries of PSTs as retrieved from their lesson plans, reflection papers and interview. PSTs' thoughts about their own knowledge in content and pedagogy were elaborated. Moreover, their thoughts in preactive, interactive and postactive stages of their teaching were tried to be explained in relation to their knowledge, beliefs and goals. Two different patterns of thoughts were determined for each metacognitive component. Then, the TPACK for effective SSI teaching of PSTs, having different metacognitive thoughts, were compared based on their scores of individual lesson plans written at the end of the semester.

CHAPTER 6

DISCUSSION AND FINAL DESIGN PRINCIPLES

The main purpose of this study was to develop PSTs' effective SSI teaching practices with technology. Therefore, an undergraduate course was re-designed to develop PSTs' effective SSI teaching practices with technology by activating their metacognition through educational design research. The results of this study ledus to reach two types of knowledge. First, this study provided information about the nature of PSTs' effective SSI teaching practices with technology and the nature of their metacognitive thoughts about their instructional practice. Since theeffectiveness of the course in developing PSTs' effective SSI teaching practices with technology was examined, the results of this study also yielded information about the characteristics of an effective undergraduate course in developing PSTs' effective SSI teaching practices with technology.

In the scope of this educational design research, initial design principles were retrieved from the literature to define the characteristics of an undergraduate course with an aim to develop PSTs' effective SSI teaching practices with technology. Throughout the cycles of the study, these principles were revised based on the data obtained from the implementations of the prototypes of the re-designed course and the iterative literature review processes. In this section, final design principles were explicated to lighten the researcher and teacher educators in their attempt to develop PSTs' effective SSI teaching practices with technology in an undergraduate course. Therefore, in the following section, the main findings about PSTs' SSI practices with technology and their metacognition were explained in relation to the design principles.

6.1. Design Principle 1: PSTs should be guided to select an SSI topic relevant and meaningful to teach and learn.

At the beginning of the study, considering the characteristics of SSI teaching and social constructivist learning environment, the first design principle of the course was determined through literature review. It was thought that in order to develop PSTs' effective SSI teaching practices, they should be guided to select an SSI topic relevant and meaningful to teach and learn. Then, the effect of case-based issues on PSTs' effectiveness of their SSI teaching was examined.

Two main case-based issues influencing the effectiveness of SSI teaching arisen as a result of the current study. First, SSI topic selection was found influential on PSTs' effectiveness in their SSI teaching. According to PSTs' statements and the observations of their teaching performances, four characteristics of the selected SSI topic were found important.

First, if PSTs selected SSI topics about which students had real-life experiences, they effectively guided students in their SSI reasoning. Since students valued the importance of the topic, their engagement to classroom discourse about the topic increased. Therefore, they could easily find evidence to support their claim and to rebut the counter-arguments.

Studies showed that life experiences are influential in shaping students' views about knowledge and learning (Zeidler & Keefer, 2003; Zeidler et al., 2005). In the resolution of an SSI, students frequently refer to their personal experience (Albe, 2008). Therefore, in order to emphasize moral dimension of teaching through SSI teaching, teachers should engage students in the analysis of real life experiences (Rattcliffe, 1997). Allowing students use their life experiences help them make meanings of complex, natural phenomena (Balgopal, Wallace, & Dahlberg, 2017; Bell, Bricker, Reeve, Ziimerman, & Tzou, 2013). Moreover, if students perceive the SSI personally relevant for themselves, they could take it seriously and develop valid knowledge claims. By this way, their learning science through SSI would be influential and relevant for their present and future social experiences (Zeidler & Keefer, 2003). Therefore, considering the role of real life experiences on students'

SSI reasoning, in this study, PSTs selected topical issues, about which students may have real life experiences, in their individual lesson plans.

Another factor influencing SSI teaching was found as the complexity of the scientific knowledge that was required for understanding the SSI. PSTs thought that if students were expected to understand more complex scientific knowledge than they were able to understand, their lack of content knowledge might interfere with their SSI reasoning. Therefore, the SSI case should be appropriate for students' level. In order to select proper SSI cases, teachers should be able to determine students' prior knowledge and developmental level to decide whether students can understand the scientific content and engage in SSI reasoning.

Studies showed that students use their scientific knowledge in decision-making (Demirci Güler & Polat, 2014; Dolan, Nichols & Zeidler, 2009; Sadler & Zeidler, 2005). Kortland (1996) gave the lack of scientific knowledge concerning the SSI as the reason for students' naïve arguments in supporting their bioethical decisions. In order to reveal the significance of content knowledge for informal reasoning about SSI, Sadler, and Zeidler (2005) conducted a mixed method research. Their study revealed that students who have low levels of understanding about the content produced more flawed reasoning. For this reason, contributing to students' decision making process by using cases appropriate for students' level was suggested (Demirci Güler & Polat, 2014). In order to increase the quality of SSI reasoning, students should be able to use their content knowledge; therefore, they should have a sound understanding of content knowledge involved in SSI topic.

The PSTs also experienced the role of content knowledge on students' SSI reasoning. They concluded that if students did not have necessary background content knowledge, they were unable to produce claims and evidences. Therefore, their engagement in argumentation processes decreased. For this reason, to be able to select and SSI topic relevant and meaningful to learn, PSTs decided to consider the content knowledge required for understanding SSI topic.

PSTs stated selecting SSI topic according to its possibility of developing care and empathy as another factor influencing the effectiveness of SSI teaching. They realized that if students showed empathy and care toward the subjects of SSI topic, their engagement increased. Therefore, they could easily produce claims and find evidences.

Research studies confirmed the role of emotions, care and empathy for the resolution of SSI (Fowler, 2008; Sadler & Zeidler, 2005; Zeidler et al., 2005). Sadler and Zeidler (2004) found that students' decision making was affected mostly by their feeling toward the characters involved in the scenarios. Therefore, their sense of care and empathy guided their negotiation and resolution of SSI. Similarly, Sadler and Zeidler (2005) argued that students' emotive responses were more than their rational responses. They stated that students' arguments were advanced and guided by their emotions like care and empathy. Emotions like empathy and care were considered as a prerequisite for moral development (Hoffman, 2000). Therefore, in order to facilitate students' SSI reasoning, moral cases arousing their emotions like care and empathy was suggested to be used.

PSTs also thought that the SSI topic should be as much specific as possible so that the students' can handle forming their claims and finding evidences to rebut the counter-arguments. PSTs stated that if they selected general SSI topics without limiting it to specific cases, students had difficulty in engaging in quality argumentation. Zeidler (1997) identified five major factors influencing the quality of scientific reasoning and stated the sampling of evidence as one of the factors. According to Zeidler (1997), if students acquire voluminous amounts of information, they could engage in fallacious reasoning. Students may give equal weight to all data sources and overemphasize a rare event in providing evidence. PSTs faced with this problem that students could not emphasize the most important arguments, rather every group tried to find evidence for different arguments.

In addition to the characteristics of the selected SSI topic, PSTs argued that their confidence in their knowledge about the selected SSI topic influenced the quality of their SSI teaching. When PSTs' metacognitive thoughts were examined, it was found that their monitoring skills were related to their confidence in their knowledge about SSI topic. Knowing all the possible arguments related to the SSI topic, PSTs easily monitored students whether they were effectively participating the discussion with quality evidences. Moreover, they could easily pursue students' arguments in discussions, because they were aware of all possible student arguments. The PSTs also stated that their knowledge about SSI topic increased as a result of their teaching. Since SSI topics were rather new in the science curriculum, PSTs might have limited knowledge of these relevant topics (Hestness, Randy McGinnis, Riedinger, & Marbach-Ad, 2011). However, it was suggested to design learning environments for PSTs to learn SSI topics (Namdar, 2018). In this re-designed course, PSTs had the chance to both teach and learn different SSI topics.

To sum up, PSTs were guided to select an SSI topic relevant and meaningful to teach and learn. To do so they were prompted in their lesson plan template to justify their topic selection. Moreover, their awareness about the influence of case-based issues on their SSI teaching effectiveness was increased through reflection papers and interviews. Therefore, they were able to criticize their teaching in terms of case-based issues. They observed the effect of case-based issues on other groups' performances and experienced it in their SSI teaching practices. At the end of the course, they reflected their observations and experiences about the influence of case-based issues on SSI teaching effectiveness into their individual lesson plans.

6.2. Design Principle 2: PSTs should be guided to consider the role of students' epistemological views including NOS beliefs in their decision-making in SSI.

Students' epistemological orientations about nature of science were considered as important in their responses to SSI topics (Simmon & Zeidler, 2003; Zeidler et al., 2005). Therefore, it was decided to guide PSTs to consider the role of students' epistemological views in their decision-making in SSI. PSTs were generally weak in including NOS objectives into their lesson plans. Either they did not write NOS objectives or their NOS objectives indicated their misunderstanding of NOS aspects. This result was consistent with the previous studies indicating PSTs' naïve beliefs of NOS (Doğan & Abd-El-Khalick, 2008; Ozgelen, Tuzun, & Hanuscin, 2013; Taşar, 2006; Yalvac, Tekkaya, Cakiroglu, & Kahyaoglu, 2007). They wrote objectives related to subjective, tentative and creative NOS that indicated their misunderstanding of these tenets of NOS. previous studies also indicated that PSTs had difficulty in understanding especially, subjective, sociocultural, tentative and empirical NOS (Abd-El-Khalick & Lederman, 2000; Dogan & Abd-El-Khalick, 2008; Yalvac et.al. 2007).

However, the number of groups and PSTs writing NOS objectives indicating the misunderstanding of NOS aspects was lower in the second implementation. The groups' SSI teaching practices were also better in the second implementation. Studies indicated the relationship between teachers' NOS views and their teaching (Tsai, 2002). There might be a relationship between their NOS conceptions and the effectiveness of their SSI teaching. Kılınç, Kartal, Eroğlu, Demiral, Afacan, Polat, Demirci Güler and Görgülü (2013) showed that PSTs' level of teaching efficacy beliefs regarding SSI decreases in case of incorporating NOS teaching. The researchers argued that due to PSTs' naïve conceptions of NOS, they had difficulty in transferring correct NOS beliefs into SSI teaching. Therefore, further studies should be conducted to reveal the effect of PSTs' NOS conceptions on the effectiveness of their SSI teaching.

These PSTs' were given explicit NOS instruction in their method course before taking the re-designed course. Therefore, it was not the aim of this research to develop their NOS understanding. For this reason, PSTs were informed about the role of NOS in SSI reasoning. Then, they were encouraged to consider NOS in their SSI teaching. Considering their areas of difficulty in understanding NOS aspects and the importance of NOS understanding in the effectiveness of their SSI teaching, it can be suggested for further research to include activities addressing NOS instruction in the context of SSI teaching in the re-designed course (Kılınç et al., 2013). Moreover, explicit NOS instructions activities were suggested to be included in teacher education programs to develop PSTs' NOS understanding (Abd-El-Khalick & Lederman, 2000). Therefore, the further attempts to revise this re-designed course should consider adding another design principle: *PSTs should be engaged in explicit NOS instruction activities to transfer their NOS understanding into SSI teaching*.

Although their instructional activities were helpful in developing students' NOS understanding, PSTs could not write related NOS objectives in their lesson plans. This may be the indicator of their weakness about teaching NOS. Therefore, in further implementations, prompting questions can be included in the lesson plan template. By this way, they can explicitly state the effect of their activities in developing NOS understanding.

There were also effective groups in both implicit and explicit NOS teaching in both implementations. Although groups' teaching activities were generally effective for developing NOS understanding of students, few groups made explicit NOS emphasis in their teaching. Therefore, their awareness about the effect of explicit NOS teaching in developing students' NOS understanding should be increased in the course.

Although they did not clearly state in their objectives, PSTs' lesson plans and teachings were effective in developing students' NOS understanding, especially sociocultural and subjective NOS. This was related to the nature of SSI teaching. In order to teach SSI, opportunities should be provided for students to evaluate a claim, analyze piece of evidences and assess multiple viewpoints related to the SSI. Therefore, engaging in these activities has an opportunity to develop students' understanding about tentative creative, evidence-driven and culturally embedded nature of science (Zeidler et al., 2009). In this study, PSTs engaged students in social negotiation through argumentation. They gave chance students to compare multiple viewpoints. Therefore, the students had the chance to see the theory-laden and socially and culturally embedded nature of science. Moreover, some of the PSTs mentioned timelines related to their SSI topic; therefore, they showed the tentative nature of science.

In addition to their own NOS views, considering students' epistemological beliefs and NOS views about their responses to SSI was also considered to change the nature of PSTs' SSI teaching. Students evaluate the evidences based on their belief systems. Moreover, students' decision making in SSI topics resembles to decisions engaged by scientists, therefore, considering students' views about nature of science during the evaluation of scientific data regarding social issues was claimed to be important in SSI teaching. Therefore, PSTs were prompted in their reflections to consider their students' epistemological beliefs. Some of the PSTs considered students' epistemological beliefs while designing their SSI teaching lesson plans.

Ozturk and Yilmaz Tuzun (2017) showed that PSTs' epistemological beliefs are related to their informal reasoning. They found that if PSTs had naïve beliefs about the certain knowledge they could not construct counterarguments. In this study, PSTs only focused on students' epistemological beliefs about omniscient authority. They believed that students do not criticize what they read in the written documents. PSTs thought that students had a tendency to accept any source of information without skepticism about the possible biased information. Therefore, the PSTs in the second implementation had concerns about their students' ability to find valid information through their internet search. Therefore, they decided to provide reliable data sources to the student. Although PSTs in the first implementation did not consider this issue, they had trouble in their teaching about this. They realized that students could not construct quality arguments and counterarguments. Therefore, these PSTs felt the need to warn their students about using reliable resources. Therefore, PSTs in both implementation decided to share resources with students in their individual lesson plans.

Prompting PSTs about the epistemological beliefs of students increased their awareness about the effect of students' beliefs on SSI reasoning. Therefore, they made changes in their individual lesson plans based on their observation and reflections about students' difficulty in criticizing data sources.

6.3. Design Principle 3: PSTs should be guided to create learning environments that facilitates the construction of shared social knowledge via discourse about SSI.

Rich and diverse classroom discussions are important in promoting scientific literacy. Engaging in argumentative discourse including the decisions about moral and ethical issues was considered a prerequisite for the development of scientific literacy (Zeidler et al., 2005). Finding pedagogical strategies to facilitate social interaction in the science classrooms has vital importance to engage students in reasoning through argumentation. Using argumentation was considered as a useful means to engage students in thinking and reasoning process, as well as imitate the daily life discourse practices in the development of scientific knowledge (Zeidler & Nichols, 2009). Therefore, it was decided to facilitate PSTs to create learning environments in which students are given opportunity to evaluate evidences as well as thoughts through argumentative discourses. In order to do so, in the comprehension stage of the course, the role and importance of reasoned argumentation were discussed.

Almost all of the groups and PSTs planned to teach SSI through argumentation. In order to facilitate argumentation, they most frequently planned to utilize cooperative learning, questioning, direct instruction, and discussions. Few groups and PST utilized 5E, online scaffolding and role playing game for their SSI teaching through argumentation. Tekbiyik (2015) showed the effectiveness of the use of cooperative learning together with writing argumentative text writing in facilitating PSTs' produce counterarguments with knowledge representing scientific literacy. PSTs also justified their use of instructional strategy referring to the literature in their individual lesson plans.

Dawson and Venville (2010) determined four factors promoting students' argumentation. These factors were stated as the role of teacher in facilitating whole class discussion; the use of writing frames; the context of the SSI and the role of students. Therefore, PSTs' implementation of written and oral argumentation into their lesson plans and teachings were analyzed. They mostly used writing frames to manage the written argumentation. Moreover, by observing the difficulties previous groups faced in managing written argumentation, later groups utilized effective technological tools allowing collaborative writing. Moreover, the later groups in each implementation used different strategies to manage oral argumentation. This improvement in the quality of argumentation toward the later groups was in line with our purpose in re-designing course. Since we wanted to create a social constructivist learning environment to develop PSTs' effective SSI teaching practices, we wanted them to reflect on other groups' performances. Therefore, by analyzing the weaknesses and strengths of previous groups, the later groups found effective strategies to boost their argumentation.

Dawson and Venville (2010) articulated the context of the SSI as another factor influencing the quality of students' argumentation. In this study, groups selected different SSI topics. They reflected on students' argumentation in the teachings. They realized the role of SSI context in the quality of students' argumentation as it was mentioned in case-based issues. Therefore, in their individual lesson plans, they tried to find more relevant SSI topics by considering the criteria they mentioned in their reflections.

The role of students was the last factor promoting students' argumentation stated by Dawson and Venville (2010). About this factor, there was an increase in PSTs' awareness from group lesson plans to individual lesson plans. In their group lesson plan, PSTs did not mention the role of teacher and students in detail. However, at the end of both implementations, PSTs were able to state a clear definition of argumentation, select argumentation for their own purpose by considering the advantages and disadvantages of argumentation, explicate their own and their students' role in the implementation of argumentation. Moreover, they developed an understanding of the role of argumentation for designing a social constructivist learning environment.

6.4. Design Principle 4: PSTs should be guided to include moral and ethical dimensions into their SSI teaching.

In the resolution of SSI, students use their culturally developed norms and values. Researchers indicated that students are moral agents and their emotions, care and empathy are influential in their resolution of SSI (Sadler & Zeidler, 2004). According to Sadler (2004b), in SSI decision making, individuals should appreciate the moral and ethical dimensions associated with the issues, because ethics and morality are inseparable components of SSI contexts. Therefore, in this study PSTs were guided to include moral and ethical dimensions into their SSI teaching. to be able to engage students moral discourse, PSTs should be aware of students' moral developmental level.

Overall, groups were not good at determining their students' developmental level in their group lesson plans. On the other hand, with the help of reflections and the teachings conducted by themselves and other groups in the course, PSTs gained more awareness about the importance of cognitive and moral developmental level of students' to attain an effective SSI reasoning. Therefore, they reflected this in their individual lesson plans.

In their group lesson plans, PSTs were not good at dealing with the moral development of their students, neither. They could not address ethical and moral aspects of their SSI. Research studies also argued that science teachers have difficulty in addressing SSI, especially the ethical and moral aspects, in their science classrooms (Develaki, 2008; Sadler, 2004b; Saunders & Rennie, 2013). The reason for the inefficiency of teachers' in addressing ethics and morality was argued as teachers' value-free conceptions of science (Levinson, 2001). However, the importance and contribution of ethical and moral reasoning were emphasized (Zeidler & Sadler, 2008). Actually, the inclusion of moral and ethical aspect into science educations is the salient superiority of SSI framework over STS approach (Zeidler et al., 2005). Therefore, increasing PSTs' awareness about the importance of addressing ethical and moral issues was considered important.

Through the reflection paper and interviews, PSTs were triggered to think about the moral and ethical aspect of their SSI teaching. As a result, the number of PSTs addressing ethics in their SSI teaching increased in their individual lesson plans. PSTs in the second implementation included ethics aspect into SSI reasoning in addition to other aspects of economics, science or legislation. On the other hand, PSTs in the first implementation mostly preferred to focus only the ethical aspect of SSI topic. However, there were some PST also in the first implementation including ethics as one of the aspects of SSI.

The topics in which PSTs addressed ethical concerns were generally genetics-related topics. Although they also covered energy-related or environmental SSI topics, they did not consider ethics in the resolution of those SSI topics. They generally focused on bioethics.

The reflections and interviews helped PSTs to understand the morality and they could address ethics in their individual lesson plans. However, they should be guided better before preparing their groups lesson plans so that they could gain experience with managing moral discourse. For this purpose, an explicit prompt can be included in the lesson plan format to guide them to include ethical aspect.

6.5. Design Principle 5: Concepts and theories about the pedagogy of SSI teaching and technology integration should be discussed explicitly.

Researchers considered the explicit teaching of the features of TPACK as influential in the development of TPACK knowledge (Angeli & Valanides, Valanides, 2009; Jaipal-Jamani & Figg, 2015; Jang & Chen, 2010). Therefore, TPACK development instructional models included activities to discuss the theories and concepts related to TPACK (Angeli, 2005; Angeli & Valanides, 2005; Chang et al., 2012; Jang & Chen, 2010). Through a series of studies, Jaipal-Jamani and Figg (2015) showed the TPACK knowledge gains of pre-service and in-service teachers who were taught TPACK explicitly. Therefore, in the comprehension stage of the re-designed course, theories about the pedagogy of SSI teaching and TPACK were explicitly taught.

Explicit teaching of the characteristics of the pedagogy of SSI teaching and TPACK was also required to engage PSTs in metacognitive thoughts. In the classrooms with a focus on metacognitive learning, students are asked to make their prior knowledge explicit and monitor the progress of their conceptions and ideas continuously in the course (Blank, 2000). Similarly, in this study PSTs were asked to make their prior knowledge, strengths, and weaknesses explicit and monitor the development of their knowledge throughout the course. Therefore, defining the knowledge required for effective SSI teaching and technology integration was important to allow PSTs monitor their development in these knowledge domains.

Explicit teaching of the theories and concepts resulted in the development of PSTs' knowledge about technology integration for effective SSI teaching. For example, PSTs were assigned readings about the patterns of informal reasoning and they discussed the examples to informal reasoning in ht comprehension stage of the course. Then, some PSTs considered fostering students' informal reasoning in determining the questions to be asked in their individual lesson plans. Conversely, PSTs generally had difficulty in determining and fostering their students' moral reasoning. Although they were scaffolded to consider moral reasoning while preparing their lesson plans, they were not effective in addressing students' moral reasoning. Therefore, more explicit instructions about addressing the ethical issues can be included in the comprehension stage of the course.

There are different theories explaining ethical thinking (Saunders & Rennie, 2013). These frameworks were argued as helpful to help teachers in their planning and teaching of SSI. For example, as Saunders and Rennie (2013) claimed, their pedagogical model for ethical inquiry provided teachers a pathway to follow in facilitating ethical inquiry in the classroom. Therefore, the models and frameworks related to the ethical inquiry should be discussed explicitly in the SSI teaching course. Otherwise, as in this study, although PSTs gain awareness about the importance of including ethical issues into their SSI teaching, they could not find ways to facilitate ethical reasoning.

6.6. Design Principle 6: Attempts to develop PSTs' effective SSI teaching with technology should align theory and practice

The researchers suggested aligning theory and practice to develop pre-service teachers' TPACK (Tondeur et al., 2012; Tondeur, Braak, Siddiq, & Scherer, 2016). Studies including short lectures or demonstrations and practical work resulted in better TPACK development (Chang, Chien, Chang, & Lin, 2012; Jang & Chen, 2010; Tondeur et al., 2012). Lesson planning was considered as an important activity in bridging the gap between theory and practice (Tondeur et al., 2016). Therefore, in this study, at the beginning of the course, theories about the pedagogy of SSI teaching and about technology integration were discussed. Then, PSTs were expected to reflect their theoretical knowledge into their technology-integrated SSI teaching lesson plans. Through implementing their lesson plans in their teaching performances, PSTs had an opportunity to refine their theoretical and practical knowledge. Then, they were again expected to reflect their refined theoretical knowledge into their individual lesson plans which they prepared at the end of the course.

The results provided evidence for PSTs refinement in their theoretical knowledge after engaging in the practice. In their group lesson plans, PSTs explained the instructional strategies they used to teach SSI, theoretically. After engaging in practice through lesson plans and teaching performance, PSTs' theoretical knowledge become more meaningful for them. Therefore, they could easily relate their theoretical knowledge with the curriculum. Moreover, in the light of their monitoring during their teaching performance, PSTs extended their theoretical knowledge. Although they could not explain the teacher role in implementing argumentation and cooperative learning, in group lesson plans, they explained the role of teacher by referring to the literature in individual lesson plans. Since they realized the importance of their role in implementing argumentation, they elaborated that part of the lesson plan by searching in the literature. Therefore, their theoretical and practical knowledge contributed to each other. The results further supported the idea of aligning theory and practice.

6.7. Desing Principle 7: PSTs should be facilitated to collaborate with peers.

Social constructivist learning environments should have necessary resources or tools for learners to reach information, to negotiate their meaning with others and to collaborate in knowledge construction (Jonassen, 1999). Collaboration was also suggested to help pre-service teachers in their learning about educational uses of technology. They should be provided an opportunity to discuss and share their thoughts with their peers (Hu & Fyfe, 2010; Tondeur et al., 2012). The researchers trying to develop teachers' TPACK through learning by design emphasized the importance of facilitating collaboration within design teams (Alayyar et al., 2011; Baran & Uygun, 2016; Kafyulilo et al., 2014; Tondeur et al., 2012).

In this study, PSTs' were facilitated to collaborate with their peers. Their reflections indicated that engaging in collaborative work contributed both to their knowledge and skills about teaching SSI with technology and their confidence to teach SSI using technology. PSTs stated that existence of more knowledgeable peer in their group was helpful in overcoming their negative feelings about teaching SSI with technology.

In order to encourage collaboration, the learning environment should include necessary tools. The learners should be able to write notes to the teacher and to the others about the project (Jonassen, 1999). Online environments can be used as the medium for sharing and discussing their ideas so that meanings can be socially negotiated. In this study, learning management system was used actively to facilitate collaboration. Since they experienced collaborative work through technology in the course, they could find effective tools to facilitate their students' collaboration.

Through collaborative teaching and learning experiences, they contributed to their effective SSI teaching practices with technology. Results showed that the quality of the lesson plans and teaching experiences of the groups whose members' were better in metacognitive thoughts was high. Therefore, the presence of more metacognitively active PSTs in the groups affected the quality of other group members' lesson plans.

However, asking PSTs to prepare the first lesson plans and to implement their plans in groups caused limitation for obtaining results for the development of individual PSTs' SSI teaching practices with technology. In order to obtain more comprehensive information to understand PSTs' individual development, the contribution of the individuals into collaborative designs could be investigated. Researchers suggested examining the nature of design talk during group-based design sessions (Boschman et al., 2015; Koh et al., 2014) in order to obtain a complete understanding about individual PSTs' TPACK development. therefore, each PSTs' contribution to collaborative work could be tracked with different data collection tools.

6.8. Design Principle 8: PSTs should be provided role models of effective SSI teaching with technology, which shows similarity with them.

Researchers showed the effect of role models in increasing pre-service teachers' motivation to use technology in their teaching practices (Tondeur et al., 2012). Therefore, exemplar cases were provided in the observation stage of the re-designed course to serve as role models for PSTs. For this reason, a video case was used including technology integration of a teacher into the teaching of an SSI topic. Moreover, guest teachers were invited to share their technology integration experiences. Besides, before PSTs started to their teaching performances, the course assistant performed a sample technology integrated SSI teaching.

PSTs were asked to reflect on the contribution of different activities conducted in the course of their TPACK development for effective SSI teaching. According to their statements, they mostly learned from each other. Effective technology integrated SSI teachings performed by their peers shaped their decision in lesson planning. According to their statements, they thought that they could accomplish when they observe their friends who accomplished effective technology integration. Moreover, they inspired from the effective teaching performances in preparing their lesson plans. Therefore, the groups and PSTs decided to use technological tools that they observed to be effective in teaching SSI in their own plans.

This result indicated the role of vicarious experiences in changing views of teachers'. Studies on self-efficacy belief and technology professional development indicated that'observing similar others' can be used as a tool for teacher development for informational and motivational contribution of them on teacher knowledge (Ertmer, 2005; Schunk, 2000). As Ertmer (2005) stated, "models can not only provide information about how to enact specific classroom strategies, they can also increase observers' confidence for generating the same behaviors."(p. 33). Therefore, this study supported the idea that studies aiming to develop TPACK for effective SSI teaching should provide PSTs role models. These models have potential to serve both as a tool to show the possible ways to accomplish effective SSI teaching through technology and to increase their confidence to integrate technology into their own SSI teaching practices.

6.9. Design Principle 9: PSTs should be scaffolded in their SSI teaching with technology experiences.

Studies showed the important contribution of the teaching experience to PCK (De Jong et al., 2005; van Driel et al., 2002) and TPACK development (Angeli & Valanides, 2009; Koehler et al., 2007). With experiences in technology use, pre-service teachers get a sense of achievement. However, they need to be scaffolded in this process to increase the effectiveness of their technology experiences. In their experimental study, Alayyar et al. (2012) indicated the potential of the support to the design teams to increase the effectiveness of their experiences.

Before enrolling the re-designed course, some of the PSTs had hesitated to use technology in their teaching practices due to the fear of failure. They stated that the positive effect of scaffolding provided by the instructor on their development of knowledge. They stated they realized their strengths and conquered their fear of technology integration into teaching.

PSTs were also scaffolded with the prompting questions provided in the lesson plan lesson plan template and reflection papers. By answering the prompting questions embedded in the lesson plan template, PSTs considered the important characteristics of an effective technology integrated SSI teaching. Therefore, they were guided to think about their plans in detail to prepare effective lesson plans. Moreover, the prompting questions provided in the reflection papers helped PSTs evaluate their technology integration experiences to decide its effectiveness. These results were consistent with the literature that PSTs should be scaffolded in their technology integration experiences in order to help them take advantage of these experiences to develop their TPACK for effective SSI teaching, because pre-service teachers' observations on technology use are not enough to test their own skills.

6.10. Design Principle 10: PSTs should be engaged in critical reflection about their technology-integrated SSI teaching practices.

Reflection was considered as important for TPACK development in terms of facilitating teachers to improve their lesson and to learn from their own experiences with technology integration (McCrory, 2008). Moreover, writing structured reflection was also considered important as a metacognitive instructional strategy (Eldar et al., 2012). A common way to accomplish metacognitive learning was stated as engaging learners in reflection practices, which includes writing what they think and how they reached that kind of thinking or analyzing the recordings of their responses in classroom activities (Blank, 2000). Some activities like discussion groups, observation and writing were suggested to help pre-service teachers for reflection (Tondeur et al., 2012).

The role of reflection was also frequently emphasized in TPACK development studies (Gao et al., 2011; Jang & Chen, 2010; Kopcha et al., 2014). However, the type of reflection being engaged in was considered important in taking the advantage of reflection in learning from practice (Mouza, 2011). While in descriptive reflection, teachers were expected to recall and describe their experiences, in critical reflection, teachers were expected to analyze their experiences by linking their instructional practices to the theoretical principles. Although both types of reflection have potential to the development of TPACK, the latter was considered as important for teachers to learn about teaching with technology (McCrory, 2008). To ensure critical reflection PSTs should be guided in their thinking about their teaching. Therefore, they were asked to write reflection papers in which prompting questions were embedded.

The results obtained from reflection papers showed that PST thought about their strengths and weaknesses in integrating technology into SSI teaching. According to their statements, while answering the questions of the reflection papers, they critically analyzed their teaching and this helped them to become more aware of their weaknesses and strenghts in technology integration for SSI teaching. Therefore, asking PSTs to write structured reflection helped them both to activate their metacognition and to learn from their practice.

6.11. Design Principle 11: PSTs' metacognition about their technology-integrated SSI teaching practices should be activated by stating the effects of being engaged in metacognitive processes on their development explicitly.

The PSTs were inexperienced in instructional planning for technology integrated instructional planning. Therefore, it is better for them to become metacognitively aware of their developing knowledge (Baylor, 2002; Hughes & Scharber, 2008). Moreover, activating their metacognition was also important to help them set learning goals and make thoughtful decisions for technology integration (Doering et al., 2009). However, in order to activate their metacognition, they should be persuaded about the utility of metacognition on their learning gains. Zohar (2012) showed that a professional development course could help teachers develop meta-strategic knowledge when if it consists of explicit instruction rather than teaching intuitively.Asking learners to think about what they are doing would not convince them to do so without offering the potential learning gains (Thomas & McRobbie, 2001). Rather, PSTs should be informed about the benefits of activating metacognition to facilitate them for the initial extra effort. Therefore, PSTs' metacognition should be activated to think about their practices in technology integration. Moreover, they should be informed about the importance of teacher metacognition for improvement of their TPACK for effective SSI teaching, so that they can be facilitated to involve in preactive, interactive and postactive thinking processes. For this reason, the effects of being engaged in metacognitive processes on their development were discussed explicitly by giving examples from the literature. Moreover, they were informed about how they can think metacognitively in different phases of their technology integration practices.by this way, PSTs were effectively encouraged to activate their metacognition.

6.12. Design Principle 12: PSTs' effective SSI teaching practices with technology can be developed by engaging them in design process.

Researchers emphasized the effectiveness of engaging pre-service teachers in design process to develop a deeper understanding of TPACK (Agyei & Voogt, 2012; Alayyar et al., 2012; Hu & Fyfe, 2010). By designing instructional materials and technology-integrated lesson plans, pre-service teachers' TPACK understanding was found to be developed. Learning by design approach provides both pre-service and in-service teachers an opportunity to develop knowledge not just of technology, content, and pedagogy, but also of their relationship to each other by providing a possibility to produce a solution with technology to an authentic pedagogical problem. In this study, we asked PSTs to design technology-enhanced SSI teaching lesson plans and enact these lesson plans in the course with their design teams, to develop PSTs' TPACK for effective SSI teaching. Moreover, they were encouraged to design instructional materials to facilitate their SSI teaching. For this purpose, groups designed presentations with different presentation tools to give students knowledge about the content knowledge and arguments related to the SSI topic. Moreover, they prepared videos with different video creation Web 2.0 tools and software to present multiple perspectives on the SSI topic. They also designed blogs and Webquests to provide resources and give instructions to the students. Furthermore, they designed and virtual classrooms in Edmodo, Beyazpano or Facebook. The PSTs designed the learning environments in such a way that effectively facilitate students' SSI reasoning.

Engaging in these design processes helped PSTs to consider different issues effective in their SSI teaching practices. Reflecting on their own and other groups' lesson plans and implementation of those plans, PSTs enlarged their understandings. Then, they prepared individual lesson plans at the end of the course by considering their thought resulting from their monitoring and evaluation of their own and other groups' teachings.

6.13. Design Principle 13: PSTs should be given opportunity to revise and adapt their knowledge for effective SSI teaching with technology.

Researchers emphasized the importance of giving pre-service teacher opportunity to revise and adapt their TPACK knowledge for effective SSI teaching. For this reason, researchers included a revision stage in their instructional model so that teachers were encouraged to reflect on their personal teaching performance for the revision of the lesson plans (Angeli, 2005; Angeli & Valanides; Lee & Kim, 2014).

As Niess (2008) stated tomorrow's teachers should be facilitated to "rethink, unlearn, and relearn, change, revise and adapt" (p.225) their knowledge. Once they were provided an opportunity to observe and practice technology integration, their abilities to adapt these skills into different technologies or different context should also be investigated and fostered. Therefore, teacher education programs should give pre-service teachers opportunity to apply their gained abilities into a variety of contexts.

Including a revision process in the instructional model has potential to promote the refinement of the lesson plans prepared by the pre-service teachers, and help them transfer their reflections to the revising activity (Lee & Kim, 2014). By this way, their reflection became more meaningful and contributed to their understanding of effective SSI teaching with technology. For this reason, PSTs were asked to reflect on their instructional practice and revise their conceptions about effective SSI teaching with technology and prepare an individual lesson plan, accordingly.

The results indicated that PSTs were able to prepare better lesson plans if they offered meaningful revision suggestions after engaging in metacognitive processes before, during after their instructional practice. Therefore, by promoting their reflection, PSTs should be facilitated to think about their instructional practice, and to revise their conceptions about TPACK for effective SSI teaching according to those thoughts about their performances.

6.14. Design Principle 14: Teacher educators should provide explicit modeling about their own technology integration into SSI teaching practices.

Researchers argued that discussing the intent of technology use through thinking aloud has a great potential in presenting thinking of the teacher educator and the pedagogy used (Lunenberg et al., 2007). Although implicit modeling has the potential to contribute pre-service teachers' technology integration knowledge under certain circumstances, explicitly modeling was found to be effective in facilitating the translation to the pre-service teachers' practices (Lunenberg et al., 2007). Therefore, to serve as a model for PSTs' instructional decisions in technology integration into SSI teaching, the purpose of the utilized technologies throughout the course was explained.

PSTs frequently referred to the technologies utilized in the scope of the course in their development of conceptions about effective SSI teaching. They stated that their views about SSI teaching and technology integration changed when they experienced the technology integration into SSI teaching in this course. They stated that the use of Wiki spaces and effective use of learning management system changed their views about technology integration. They experienced the potential of collaborative writing tools, such as wiki, in facilitating their group works. Then, they utilized different collaborative writing tools to facilitate their students' argumentation by leading them to share their arguments with each other. Moreover, since they admired the functional usage of learning management system in the course, they utilized different e-learning environments that can serve as a learning management system such as Edmodo. They managed their instructional activities through these tools. PSTs' emphasis on the role of used technologies in the scope of the re-designed course in their development of TPACK for effective SSI teaching also indicated the positive effect of explicit modeling of technology integration. Therefore, explicit modeling of usage of technologies, which have the potential to increase the quality of SSI teaching, was suggested for further design attempts.

6.15. Conclusion

The results of this study yielded information about the nature of PSTs' effective SSI teaching with technology. When their planning and teaching performances were examined, all of the PSTs used argumentation in their teaching. While some of the groups defined their main instructional strategy as cooperative learning, 5E and jigsaw, all of them included argumentative discourse (written or spoken) in their plans or teachings. Although they were weak in integrating technology into their teaching to facilitate their implementation of argumentation at the beginning of the course, the groups' instructional practices became better in this sense. Based on their observation of good teaching practices performed by the former groups, PSTs effectively integrated technology into their SSI teaching in their lesson plans. Therefore, the quality of implementation of argumentation and technology integration into SSI teaching increased from the first groups to the last groups. They mostly utilized technology to introduce concepts and phenomena to students, to show the multi-perspective nature of the SSI topic, to let students search evidences for their arguments, to allow communication among students for effective idea sharing, and to guide students in these processes.

Since PSTs needed to examine the curriculum to prepare their group lesson plans, their curriculum knowledge was also good in individual lesson plans. They could easily relate the SSI topic with the curricular objectives. Moreover, they became aware of the emphasis of the curriculum on argumentation and technology usage. Moreover, their conceptions about the nature of SSI became elaborated. While some of the groups had difficulty in deciding a topic that has the characteristics of true issue, they realized the characteristics of SSI topics at the end of the course.

PSTs was not much effective while determining their SSI topic by considering the appropriateness to the students' developmental level. While some of the groups had awareness about this, most of the groups and PSTs could not evaluate the appropriateness of the selected SSI for the target students. If PSTs had awareness about this, they tried to select a more local or topical issue to increase their students' engagement in the argumentative discourse. These PSTs' also concerned about the appropriateness of the issue for moral and ethical reasoning. However, the number of these PSTs were quite low.

PSTs were generally weak in addressing the moral development of the students. Moreover, although they could effectively decide the related background knowledge and possible misconceptions that students have, PSTs were not good at designing instructional activities by considering this information.

PSTs were least effective in their assessment with technology. They could decide neither what to assess nor which technologies to use for assessment. Most of them could not effectively assess students' scientific, informal and moral reasoning. Neither did they assessed their students' content knowledge gains.

PSTs' metacognitive patterns were found to be related to the quality of their technology integration into SSI teaching. If they were engaged in productive metacognition regarding their instructional practice, they were able to prepare high quality lesson plans. On the other hand, if they were engaged in less productive metacognition regarding their instructional practice, they could not plan effective SSI teaching lessons by integrating technology. If PSTs' metacognitive thoughts in interactive stage were productive, they enacted their lesson plans effectively. On the other hand, if their metacognitive thoughts in interactive stage were not productive, the qualities of their teaching were lower as compared to their lesson plans. That is, although they prepared effective lesson plans theoretically, they could not effectively put their plans into action if they could not monitor and regulate their teaching effectively.

The results also yielded information about the characteristics of an undergraduate course with an aim of developing PSTs' effective SSI teaching practices with technology. The groups' and individuals' SSI teaching were generally better in the second implementation. Moreover, PSTs in the second implementation was engaged in more productive metacognition about their instructional practice. Although they were not the same group and there may be differences in their conceptions about SSI teaching and technology integration into SSI teaching, some inferences were done for the causes of these differences from the changes in the prototypes of the course. Moreover, in the discussion, the final design principles were discussed by combining the findings of the study and the literature. Based on the weaknesses of the activities conducted in the course, suggestions were provided for further studies under each design principle.

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APPENDICES

A. TPACK LESSON PLAN TEMPLATE

TPACK LESSON PLAN

SECTION 1

Grade: ....

Topic: ....

Unit: ....

Duration: ....

SECTION 2

Learning objectives:	Include the objectives from “knowlege”, “skill”, “affect” and “STSE” learning areas.	
Content:	What is the academic subject material to be taught?	What is the socioscientific issue you selected to teach this content? ....
Student background :	What prior knowledge do students have that is relevant to this lesson and how will you activate them?	

....

....

What are the possible misconceptions that students have? How will you elicit them?

....

....

....

How appropriate the issue you selected for students' developmental stages? Why?

....

....

....

Instructional strategies:

- What is your teaching strategy? (e.g. cooperative learning) Explain the main point of the teaching strategy you have chosen**.**
- What are the affordances and constraints of the strategies**?**
- Why is it a useful teaching strategy? Explain the reasoning underlying your selection of teaching strategy for this particular topic. You can justify your selection by providing evidence from the literature.

....

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....

....

Teacher/ Student role:

Explain how the teaching strategy you selected is conducted. Mention how the teacher and student role will be according to the teaching method and strategy you selected. Justify your explaination by providing evidence from the literature.

....

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....

....

Instructional materials and

	Teacher use	**Student use**
	• Write the materials and technologies you will use. Explain how you will make	• Write the materials and technologies that will be used by student. Explain how students

technologies:	use of these materials and technologies. • What instructions with the technology should you give to students prior to their work?	will make use of these materials and technologies. • What worksheets/handouts are you planning to give students with information and instruction for working with the technology? • How will you assess the students' understanding of the instruction about the technology? • What preperation will the students need for successfully using the technology as a tool for learning the subject? ....
Constraints/ possible problems of the selected instructional technologies and solution suggestions:	• What might be the possible problems of technologies that you have selected in your teaching? What do you suggest to solve these problems?	
The relationship between the selected instructional technologies and the subject area:	• Why are these technologies important especially for this particular content? • How will the use of these technologies support the learning of the subject matter ideas?	
The relationship between the selected instructional technologies	• Why are these technologies important especially for this particular teaching strategy? • If the lesson incorporates hands-on use of technology by students, will the students have been prepared to work individually or in small groups with technology? How?	

and instructional strategies:	• If the lesson incorporates hands-on use of technology by students, will all students be involved and held accountable for learning in the hands-on experiences? How? • What will the teacher do while students are working with technology? • How will the teacher assure that students are making progress and that the technology is working? ....

SECTION 3

Entrance/motivation activities:

Explain how you will start the lesson and motivate the students.

(Spaces are not the indicators of the amount of required explanation. Please be comfortable to use as much space as you need.)

Lesson flow / Activities:

Explain the flow of your lesson. Please include the answers of the following questions to your explanation.

- How will the flow of the lesson prepare, motivate, and encourage the students to engage in the experience?
- What questions will be proposed for engaging the students in the ideas and assessing student understanding?
- How much time do you estimate reasonable for each of the activities in the lesson?
- How will be your directions and transitions to assure student understanding and maintain student attention? What will be the closure procedures?
- Will there be a closure to the lesson that integrates considerations of what they learned with the technology? How?

Suggestions for the case of falling behind or being ahead of the schedule:

- What are you planning to do if students finish early?
- What are you planning to do if time runs out and students did not finish the activities?

SECTION 4

Assessment strategies:

Explain the assessment strategies you will use before, during or after your teaching. Explain how and for which purpose you will use these strategies.

- What will you do to assess both your students' understanding and your teaching?
- What, if any, will be your diagnostic, formative and summative assessment strategies?
- What will be your strategies to monitor your teaching experience throughout the lesson?
- How will you use the data about students' understanding and thinking during your teaching?

SECTION 5

Reflection: (This part will be filled after microteaching performance)

Reflect upon your micro-teaching experience. Please include the answers of the following questions to your explanation.

- What kind of troubles did you face in your teaching and how did you try to handle them?
- How well did you accomplish the goals of the lesson?
- How much did your teaching fit with your purpose?
- How much did your teaching correspond to your lesson plan?
- To what extend did you elicit all students' prior knowledge/skills that are needed for this lesson?

Suggestions: (This part will be filled after microteaching performance)

Propose suggestions for your future lessons based on your micro-teaching experience.

- Is there any easier and more effective way to teach the same topic?
- What should you do not to face with the similar troubles in your future lessons?

B. SAMPLE GROUP LESSON PLAN

GROUP 6 SECTION 1 **5**
Grade: 5th Grade Topic: Relationship Between Human and Environment Unit: Living Creatures and Life Duration: 60 Minutes

SECTION 2	
Learning objectives:	• *Researches the human-caused environmental problems to make suggestions on them. (STSE)* • *Identifies features of Black Sea Region. (Cognitive-Knowledge)* • *Cooperates in discussion with the group members in order to reach a decision. (Affective- Responding)* • *States supported ideas with the evidences about the given topic. (Cognitive-Comprehension)* • *Communicates with the group members to form well-supported claims. (SPS- Communicating)* (Spaces are not the indicators of the amount of required explanation. Please be comfortable to use as much space as you need.)

Content:	• What is the academic subject material to be taught? *Fifth grade elementary science curriculum includes a topic named the relationship between human and the environment. In this topic, the objective "investigates the environmental problems which are caused by human" is provided. In this specific lesson, teacher satisfies the objective that is mentioned above by STS teaching, providing a socio-scientific issue that related with the objective and, expect students to achieve that objective.*	• What is the socioscientific issue you selected to teach this content? *Teacher satisfies the objectives through the socio-scientific issue "Yeşil Yol Project". Yeşil Yol project is a plan of a road that connects the forty flatlands in eight cities in eastern black-sea region. There are both positive and negative opinions about the construction of the road. Some of the people who live in the region want the road and they believe that the road will have positive effect to the region. However, some people who live in the region believe that the road will have negative effect to the region. General opinions can be clustered under three main categories which are transportation, tourism and employment rate. Accordingly, students will do an argumentative lecture to discuss the positive and negative effects of the road and, reach an agreement about whether the road should be constructed or not.*

Student background:	• What prior knowledge do students have that is relevant to this lesson and how will you activate them? *Students know the precautions to protect environment from air, water and soil pollution from the 5th grade (unit : our planet Earth)* *Students know the relationship between the composition materials of Earth and our lifetime requirements and the*

	negative effects of pollution in our lives from the 4th grade (unit : Earth and universe) • What are the possible misconceptions that students have? How will you elicit them? *Students do not consider avalanches and landslides as a natural disaster.* *Students do not consider natural disasters that cause loss of money and lives.* *In order to eliminate this misconceptions, teacher says that avalanches and landslides are the common natural disasters that occur in eastern black-sea region and, these events cause loss of money and lives in the region.* *Turan, İ. & Kartal, A. (2012). İlköğretim 5. sınıf öğrencilerinin doğal afetler konusu ile i lgili kavram yanılgıları. Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi, 13(3), 67-81* • How appropriate the issue you selected for students' developmental stages (cognitive and moral)? Why? *About our issue, students made an activity based on discussion. According to their claims, they tried to find some evidences that support their claim. This process, students actually tried to make researches scientifically as scientists. It has a positive effect on students' development cognitively because this way, they know, what they do in order to reach any information or data. By using online sources, they find evidences and they made a decision with their group members in order to reach a co-decision. It contributes to improve the ability of decision making of students. On the other hand, our issue affects human directly. After the road building, we talked about that many people' way of living will change. For example many agricultural areas/fields are affected after Yeşil Yol Project. It helps students to show empathy towards the people live in black sea region. They can adopt the case or issue easily and it contributes them to find solutions. The human-based*

	problem solving ability affect directly to the moral development of students.
Instructional strategies:	• What is your teaching strategy? (e.g. cooperative learning) Explain the main point of the teaching strategy you have chosen**.** • What are the affordances and constraints of the strategies**?** • Why is it a useful teaching strategy? Explain the reasoning underlying your selection of teaching strategy for this particular topic. You can justify your selection by providing evidence from the literature. *According to Eemeren and Groontendorst, argumentation is a social activity in which an individual tries to convince others either through talk or writing about the validity of a particular assertion. Moreover, argumentation refers to the process of constructing an argument and its justification while the term argument refers to its substantive content. There is some advantages of using argumentation in science classroom which are;* • *Achieving scientific literacy* • *Developing conceptual understanding* • *Assisting in the development of NOS understanding* • *Developing decision making about SSI* • *Supporting critical thinking&reasoning* • *Comprehending epistemological basis of scientific practice* • *Understanding science as a social practice* *In argumentation teaching strategy, it is important for students to consider several steps which are;* • *Claim: In this step students form their own claims about the particular content.* • *Justification: In this step students support their claims with evidences.* • *Counter-position: In this step students consider what might be the critics for their claims.* • *Rebuttal: In this step students finds evidences in order to rebuttal the opposing ideas to their claims.*

	Teachers may use different kind of argumentative techniques during science education which are; • *Competing theories(cartoons)* • *Competing theories(ideas&evidences)* • *Competing theories(story)* • *Concept maps* • *Construction of an argument* • *Table of statements* • *Report of tan experiment* • *Prediction, observation and explanations(POE)* • *Design of an experiment* *Here is some articles that emphasize the use of argumentation instructional strategy in teaching SSI content.* *Sadler, T. (n.d.). Engaging Students in Scientific and Socio-Scientific Argumentation. In Socio-Scientific Issues in the Classroom: Teaching, Learning and Research (pp. 193-196). Florida.* *Zeidler, D., & Nichols, B. (2009). Socio-Scientific Issues: Theory and Practice. Journal of Elementary Science Education, 21(2), 52-52.*
Teacher/ Student role:	• Explain how the teaching strategy you selected is conducted. Mention how the teacher and student role will be according to the teaching method and strategy you selected. Give specific examples from the flow of your lesson plan to explain the teacher and students roles. Justify your explanation by providing evidence from the literature. *Teacher role in argumentation technique is to encourage discussion, defining the argument, encouraging students to share ideas, checking evidence base of students, providing evidence for students, encouraging students to make presentations, encouraging evolution, encouraging students to anticipate counter arguments, encouraging reflection and asking students if they changed their minds. Shortly, teacher is a facilitator during an argumentation. Student role in argumentation is to produce claims, support their claims with evidences, and consider the counter arguments and rebuttal the counter arguments.*

	For example, in our lesson flow, teacher facilitates the evidences about the selected socio-scientific issue, encourage students for discussion, define the argument, encourage students to share their ideas, make predictions, anticipate counter arguments, reflection and ask students if they changed their minds through wordpress and google documents. However, students will produce claims, support their claims with evidences, consider the counter arguments and rebuttal the counter arguments during group discussions and the teacher will observe students during discussion. After the discussion ends, students will share their ideas through the google documents. *Sadler, T. (n.d.). Engaging Students in Scientific and Socio-Scientific Argumentation. In Socio-Scientific Issues in the Classroom: Teaching, Learning and Research (pp. 193-196). Florida.* *Zeidler, D., & Nichols, B. (2009). Socio-Scientific Issues: Theory and Practice. Journal of Elementary Science Education, 21(2), 52-52.*

	Teacher use	**Student use**
Instructional materials and technologies:	• Write the materials and technologies you will use. Explain how you will make use of these materials and technologies. (Write the links, names of programs, or anything you will use in the lesson. If you will use different types of files, attach them to the "files"	• Write the materials and technologies that will be used by student. Explain how students will make use of these materials and technologies. *Students use "Kahoot" before the activity to see if there are some missing knowledge or unclear parts about Yeşil Yol Project and if there are some students who did not understand some information*

	tab of your wiki page.) *In teaching part of the lesson teacher uses "powerpoint program" to give some information to the students about the selected socio-scientific issue. The slides are prepared simple for students to follow and there are some photographs and tables of statistical analysis of some particular features of the cities that are included to Yeşil Yol Project.* *In teaching part of the lesson teacher also shows some part of a documentary about this Project and how it will ease the transportation of this area and summarizes the features of this road to emphasize the need of transportation in Black Sea region.* *In activity part of the lesson firstly teacher assesses students' knowledge about Yeşil Yol Project and tries to cover the missing parts or some parts that are not clear for the students. Therefore teacher uses "Kahoot" application to evaluate students understanding by the help of technology.* *Moreover, teacher uses "google documents" to collect the ideas of each group by the help of technology and to help students to have more healthy discussion environment and not to have conflict during the discussion. In this way teacher also can follow the discussion and*	*about Yeşil Yol Project can ask before the activity and teacher can review and they can have better discussion.* *Students also use "Google Documents" in order to write their claims and see opponent claims of theirs and in this way, students can easily follow different ideas and justify them.* *Moreover, students use "Wordpress" page to find evidences for their claims and have an oriented discussion. It also can help students to make decision in a short time.* • What worksheets/handouts are you planning to give students about information and instruction for working with the technology? *Teacher does not distribute any specific worksheets or handouts about the usage of the technology. However, teacher clearly explains the usage of each technological tool which are kahoot, wordpress and google documents verbally. In addition to the verbal explanation, teacher demonstrates how students can reach and use the technological tools on the projection screen.* • How will you assess the students'

	performances of each group. *In activity part teacher also uses "wordpress" to provide evidences about their claims and some sources that they can get more information about the Yeşil Yol Project. In this page each group can find their evidences in related part and therefore it make it easy for them to find evidences for their sides and there will be no time consumption during this stage.* *scneforese.wordpress.com /category/home* *https://scnceforese.wordpress. com/?ref=spelling* *kahoot kullanıcı adı: XXXXXXX@gmail.com* *kahoot şifre: XXXXX* *https://play.kahoot.it/#/k/24a83b55-1148-40ff-81f5-f573b13e1ee2* • What instructions with the technology should you give to students prior to their work? *Before starting the activity students should be informed about the technological application that they will use during the activity. Teacher informs students about "Kahoot" application and how they will enter the quiz. Teacher writes the password to the board and shows how they will enter the game. In addition, teacher informs students about other websites that they will use and gives the links of these*	understanding of the instruction about the technology usage? *While assessing the student's understanding of the technology usage, teacher can use the provided performance based assessment rubric. Teacher can assess the student's understanding about the technology usage through the parts "performance on the whole" and "understand the task" on the performance based assessment. Teacher can write his/her observations on the comment section.* • What preparation will the students need for successfully using the technology as a tool for learning the subject? *Students should download Kahoot application to their smartphones in order to join the game before the activity.* *Student also should have computer to be active in discussion part.*

	websites also writes them to the board.	

Constraints/ possible problems of the selected instructional technologies and solution suggestions:	• What might be the possible problems of technologies that you have selected in your teaching? What do you suggest to solve these problems? *Before announcing the activity, teacher informs students about Kahoot, there can be a problem related to the log in part. Teacher gives students password for entering the game and writes it to the board if it's necessary. However, it may cause time consumption because students may have trouble in entering the game an there may be noise or students may have problem in seeing the password on the board or on the projector. Teacher should be careful about following each student. If they realize any problem, s/he should interfere to solve without distracting any student. Some students may have trouble in entering stage of Kahoot because of their internet connections and even if there exists such problem teacher should show the questions and the answers by the help of projector so that none of the students lose their interest to the game and miss the information that are intended to review before the activity. In addition, there may be some students who do not have smartphones and so they cannot join the game however because teacher shows each items and review them to the class, these students will understand and enjoy even if they cannot enter the game and also teacher may ask students to share their phone with these students and answer together. Moreover, the prepared quiz in Kahoot may not work, and to solve this problem teacher should check the quiz and each item before the lesson and if it does not work teacher should summarize all the important points that are intended to be given by the quiz.* *About wordpress, teacher will give brief information about the technology and it's usage. The wordpress includes well-prepared sources for students and at the homepage, there are clear directions about which sides*

	they are belong to and which claims they need to give importance. In the home page there are two main parts; 'We want Road' and 'We do not want Road'. With this classification, student can access sources related to their claims easily. However, if the informative part takes a long time, the time for argumentation with online discussion will decrease. Also it can affect the time of summarizing part. Teacher should follow and announce the activity time/remaining time carefully and frequently. In wordpress there are some links that students should access and if these links of the evidences do not work students cannot have a healthy discussion and it also affect the decision part of the lesson because some students cannot accept the claims that students find without addressing the evidences. Moreover, some students may find wordpress page confusing and cannot find the related sources or some students may find sources to long to read. Therefore, teacher summarizes each evidence in the related part and also provides the original sources. In addition, teacher always should be active during the activity to help students who have problem in finding sources of evidences and the webpage. *During online discussion, there can be a problem related to the internet connection. If it is cut off, teacher can direct or motivate students to do their discussion in different way. For example, instead of writing the claims to "google documents" teacher asks students to write their claim and evidences to the paper and then asks them to read the paper of opponent group until and discuss about the ideas until the problem is over. In this way, teacher can prevent any loss of time and help students to continue the discussion.*
The relationship between the selected instructional technologies and the subject area:	• Why are these technologies important especially for this particular content? *Because it is a socio-scientific issue by the help of technology students can share their ideas or claims easily and decision making process can be easy for them. Students can also realize that if they face with such an issue in their lives they should think all the different ideas and they should find reliable sources to shape their ideas and after these activity students*

	understand that it is necessary for them to use technology and search for the evidences of their claims in different types of sources such as articles, books etc. In addition, students need to understand the features of this region in order to make decision about road building however it is really hard to make decision about road building if students did not see the Black Sea Region and therefore by provided videos and sources it may be easier to picture the conditions and the features of these places. • How will the use of these technologies support the learning of the subject matter ideas? *By using technological application and accessing the reliable sources from internet students can learn different ideas and how they are related to this socio-scientific issue that they will discuss and they can better internalize the information and knowledge about this region and apply them to the daily life problem. Students can better learn how they can use technology while making discussion and how they can find well-supported claims with evidences from the given sources by using technology. In addition, by the given sources and information from the wordpress students can get all the information about the topic and by using online argumentation page they can better understand opposite claims of others.* • How will the use of these technologies support students' understanding of the socio-scientific issue? *Students can easily understand that socio-scientific issues are the important to discuss together because there is no right or wrong answers and they need to evaluate both negative and positive sides of the issue. Technology makes it easy to discuss such issues and have better oriented ideas with the evidences. Since socio-scientific issue needs whole class participation and opinions of each student when teacher uses*

	technological applications that allow students to share and justify the ideas, the lessons that are done to teach socio-scientific issue should be well-integrated with the technology.
The relationship between the selected instructional technologies and instructional strategies:	• Why are these technologies important especially for this particular teaching strategy? *Technology is important especially for argumentation method because it has several benefits in preceding the activity. For example, technology helps students to understand their roles in a short time because by provided sources of their roles and also related classifications in the "Wordpress" they can easily understand their sides and create their claims in consideration of opponents' claims. However, if this lesson will be done without using technology it might be confusing for students to follow and understand their roles and it might take too much time. Moreover, the time is spent by creating claims, making decision and writing them to show the ideas to the opposing group may be too long without technology and in argumentation activity it is important to use time influentially for improving students' critical thinking, communication skills and also cooperative learning abilities and if the students consume time with finding evidences to support their claims during the activity these skills cannot be improved and the activity may lose its effectiveness.* • If the lesson incorporates hands-on use of technology by students, will the students have been prepared to work individually or in small groups with technology? How? *Working with small groups will be efficient for critical thinking. Students can analyze the information related to evidence better with their group mates. It also contributes to infer some consequences with the help of more than one opinion. Besides, about technology*

	usage, it has benefits to work in small groups because if there is any problem with the technological application or misunderstanding related to the activity, they may have chance to overcome the problem themselves firstly. Then, it may develop students' problem solving skills. • If the lesson incorporates hands-on use of technology by students, will all students be involved and held accountable for learning in the hands-on experiences? How? *If small groups include 2-3 students, it will be easy to follow and participate in terms of both time management and decision-making process. Teacher may design their technological materials with some division of labor. Teacher can give mission to students one by one. Or, s/he can prepare the material with some steps. By this configuration, students cannot see and solve other question or problem without finishing previous mission. It contributes cooperative learning and involvement to the activity.* • What will the teacher do while students are working with technology? *Teacher should be active during the activity in order to give directions to the students and also help students in usage of technological applications. Because some students may have trouble in accessing applications and websites and in such situations teacher should interfere in order to prevent the loss of attention of students to the activity and grab student interest to the discussion part. Teacher also should emphasize what is expected from them in discussion part and also warns students about the remaining time because it is important for students to learn how to work effectively with group members in a limited time. Teacher also should help students who do not participate the discussion. Therefore, teacher always observes students performances during the activity and tries to make them active by asking simple questions or giving duties to*

	these students. Teacher also should be prepared about technological failures. For example, if one of the computers does not work, teacher should provide the other one or if there is no internet connection then teacher should review all the evidences to the students and want them to make decision after revision of the claims. • How will the teacher assure that students are making progress and that the technology is working? *Teacher should follow all progress and addition of the claims and evidences in her/his computer and if one of the groups cannot find a proper claim and evidence or cannot manage with the time teacher interferes and helps students to make progress by giving directions.*

SECTION 3
Entrance/motivation activities:
Explain how you will start the lesson and motivate the students. *Teacher greets students and summarizes what they did in the last lesson: "Hi everyone, do you remember last lesson we talked about Yeşil Yol Project which is planning to be done in Black Sea Region."(Expected answer: Yes, it is about a road building in that region and it will pass through eight cities and will combine the forty flatlands in these cities. If teacher cannot get the answer from students, s/he reviews the project again.) Teacher explains what how the lesson will continue: "Firstly, I want you to remember some important points in that topic and for this reason we will make a quiz from Kahoot application. Did you download the application as I told you last lesson?" (If the students did not download the application, teacher helps and waits for them to download.) (Kahoot application is used to motivate and grab students' attention) Then teacher shows the password in the projector and wait for students to enter the game: "As you see, you can enter password in this button and this is the password for the game. I will wait for all of you to enter the game then we can start our quiz." (Teacher waits for students to enter the game then starts the quiz.) "If you are ready we can start." Teacher waits for students to answer the question 1 then summarize the answer of the question 1(Cognitive-Knowledge): "In Black Sea Region the average height of the mountains 4000 m and if you remember we emphasized the geographical features of this region and we said there are lots of high mountains which make the transportation hard for the people." Teacher continues with the second question and waits for students to answer the question 2 and summarizes the answer(Cognitive-*

Knowledge): "Last lesson we talked about some natural events that occurs in this region frequently such as fog formation, landslides and avalanche and we said landslides occurs very often and may damage the road and will not allow people to use the road"(Misconceptions: Students do not consider avalanches and landslides as a natural disaster. Students do not consider natural disasters that cause loss of money and lives.) Then teacher waits for students to answer the third question and then summarizes it: "If you remember we talked about some protected areas such as Sümele monastery and we said there are 202 protected areas in that region and the road will make it easier for people to visit these places." Teacher waits for students to answer the fourth question and then summarizes it: "Last lesson we said that people who live in this region are worried about tourists and think that they will not be careful about the protection of environment and they may even leave their trashes in the nature. In addition people say that they carry their trashes to the city center and tourists will not do the same thing for the nature." Teacher continues with the fifth question and then summarizes it: "If you remember we talked about unemployment rate in the Black Sea Region and we said Trabzon has the highest unemployment rate in this region because there are lots of people who migrate to Trabzon to find job." Finally, teacher waits for students to answer the sixth question and summarizes it(Cognitive-Knowledge): "In the last lesson, we also talked about specific plants that grow in that region such as nut, tea etc. and we also said that this region is the only place that is suitable for tea plant in Turkey"

Lesson flow / Activities:

Explain the flow of your lesson. Please include the answers of the following questions to your explanation.

- How will the flow of the lesson prepare, motivate, and encourage the students to engage in the experience?

Teacher shows the scores of students and explains the activity part of the lesson:

"Now, we will make an activity about Yeşil Yol Project. In this activity you will be villagers and discuss if you want this road or not. You will discuss it according to your roles which I'm distributing now. Some of you will discuss it in terms of transportation, some of you will discuss it in terms of tourism and some of you will discuss it in terms of employment.(Affective-Responding) Moreover, in each aspect there will be proponents and opponents. I will show you where you will sit and in which group you are by projector. (to prepare students to activity) As you now it is a current issue related to our own country and I believe it is important to have such activities in our lessons to understand how the society makes decisions about current issues and how can we share our ideas and respect to others ideas."(to motivate and encourage the students) Teacher explains the usage of technology for the discussion part: "From the computer that I distributed to each group, you should enter "wordpress" website. I will write its name to board and show how it works by projector." Teacher shows how students can

enter wordpress blog: "You will find some sources under your groups and also there are links to the google document which you will use to write your claims etc. You need to search for the evidences to your claims; you can use sources that I provided you or other sources that you find in other articles or books etc.(STSE) You will discuss about 15 minutes. (SPS- Communicating) . You also need to select one students from each aspect so that they can represent your ideas then we will have panel with these students and try to have a common opinion about the project. If you do not have any questions you can start."

- What questions will be proposed for engaging the students in the ideas and assessing student understanding? What would be the possible answers of the students to your questions?

At the final discussion, teacher asks the students who represent their groups to come to their place in front of the class so that they can start to panel. Teacher asks the final decision of each group in each aspect. Firstly teacher asks what the students in transportation group think about the Yeşil Yol Project(Cognitive-Comprehension): "What is your claim and what do you think about the Yeşil Yol Project?"(in this way teacher examine students' understanding of the project) Two students in transportation aspect talk about their opinion and if they cannot reach an agreement teacher directs the students by emphasizing the important points of their claims such as their concerns and supporting points and asks them to reconsiders opponents and proponents ideas and decide whether they support or are against the road as a final decision.(Affective- Responding) When students reach an agreement teacher writes their decision to the chart on the board to make it easier for the other students to follow the panel. Teacher follows the same steps for the students in each aspect and writes their decision to the board. If all the students agree upon one side then teacher summarizes the panel and if there is not an agreement on one side then teacher asks students in the panel to discuss and try to make an agreement. Then if the students have one common side teacher summarizes the panel and if not teacher helps the students to create conditionally agreement and closes the panel then summarizes it.

- How much time do you estimate reasonable for each of the activities in the lesson?

-15 minutes for Introduction and the Kahoot Quiz.

-10 minutes for grouping the students and explaining the discussion procedure according to proponent and opponent ideas.

-15 minutes for discussion between group members in aspects of transportation, tourism and employment.

-15 minutes for the ending discussion for arriving a final decision in community wheter the Yeşil Yol Project is beneficial for our country or not.

-5 minutes for the brief summary of the topic and giving assignment of the lesson.

- How will be your directions and transitions to assure student understanding and maintain student attention? What will be the closure procedures?

In order to maintain student's attention, teacher conducts a panel instead of letting all students to argue with each other at the end of the lesson. By conducting a panel, teacher takes all the students attention at one point. Moreover, teacher constantly paraphrase and repeats the students ideas at the panel about the issue in order for other students to follow the discussion easily. In addition to paraphrasing and repeating, teacher draws a chart on the board about each group's agreement for other student's to follow easily. At the end of the discussion, teacher summirazes the all discussion and finish the lesson.

- Will there be a closure to the lesson that integrates considerations of what they learned with the technology? How?

Teacher reviews which technological instruments and applications students used during the whole activity to search for evidences and communicate with other groups. In addition, teacher emphasizes the importance of the usage of technology in such activities and also emphasizes that by using technology they can reach better solutions and decisions and they can be faster and easier.

Suggestions for the case of falling behind or being ahead of the schedule:

- What are you planning to do if students finish early?

If the class finishes early, teacher can review the proponent and opponent ideas about the project and also teacher can talk about the details of concept map which is asked for the next lesson.

- What are you planning to do if time runs out and students did not finish the activities?

Teacher can give directions to the groups and help them to reach an agreement. Moreover, during the discussion teacher may warn students about the time.

SECTION 4

Assessment strategies:

Explain the assessment strategies you will use before, during or after your teaching. Explain how and for which purpose you will use these strategies.

- What will you do to assess both your students' understanding and your teaching?

Constructing concept maps are useful in many ways such as allowing quick interpretation, illustrating the hierarchy of ideas, visualizing the outcomes and evaluation of the ideas. Since the Yeşil Yol project is an socio-scientific issue, it is important for students to form clear ideas about the proponent and opponent ideas about the issue and, understanding the relationship between the ideas. Thus, teacher asks students to draw a concept map showing all the proponent and opponent ideas and, the relationship between them in order to see how clear is the concepts in student's minds and if they are able to reflect what they have learnt in a schematic way.

- What, if any, will be your diagnostic, formative and summative assessment strategies?

Diagnostic assessment provides information about each student's prior knowledge about the content. Therefore, a teacher can use these data's at the beginning of the lesson and differentiate his/her main points according to the missing parts of the students' knowledge. In that manner, we can consider the Kahoot program as a diagnostic assessment strategy because teacher uses the program in order to see the student's prior knowledge at the beginning of the class. However, in this specific lesson plan, teacher does not use the formative and summative assessment strategies.

- What will be your strategies to monitor your teaching experience throughout the lesson?

During argumentation process, In order to monitor our teaching experience we are going to do a performance based assessment according to rubric below;

Rating Criteria	*Good / Bad*	*Comments (If any)*
Understand the task		
Division of labor		
Interaction with group members		
Body Language/Gestures/Mimics		
Performance on the whole		
Involvement to the discussion		

- How will you use the data about students' understanding during your teaching?

At the beginning of the lesson, teacher uses Kahoot program in order to check whether students understand the concepts about the socio-scientific issue or not. Kahoot program provides a general information about the student's understanding about the concept. Therefore, teacher uses Kahoot results in order to see the general understanding of students and, emphasizes the missing parts about the content more carefully. Moreover, teacher quickly reviews the missing parts of the student's information.

C. REFLECTION PAPER QUESTIONS

REFLECTION PAPER-I

This reflection paper will be written after the introductory lectures. Each participant will write the paper individually by answering the following questions.

Please include the answers of the following questions in your reflection paper.

Write about your thoughts after class discussions

1. What do you think about the role of technology (both technology integration and technology education) in science teaching?
2. After the class discussions about the role of technology in science teaching, have you noticed any changes in your ideas? If there are any changes in your ideas, what made you change your ideas?
3. During the class discussions, what were the differences between your ideas and other classmates' ideas about what teachers should know for effective technology integration?
4. After the class discussion, which of the ideas about the teacher knowledge required for technology integration were more attractive to you? Why?

Write about your thoughts based on your own experiences

5. What were the instances you experienced effective science lesson in which technology integrated successfully throughout your education life? Why do you think it is an effective example?
6. What were the topics that are difficult or impossible for you to understand without technology? If technology was integrated in teaching of these topics, how it would affect your understanding?
7. How could you integrate technology to enhance student understanding in the topics you mentioned in 6^{th} question?

Write about your thoughts on your TPACK

8. What does technological pedagogical content knowledge mean to you?
9. Draw a concept map to explain your understanding of TPACK.
10. Based on your understanding of TPACK, how can you rate yourself? Please assess your current knowledge domains by choosing the number that best represents where you believe you would align yourself.

- What is your technology knowledge in the classroom?

  1 = Novice and 5 = Expert

  1 2 3 4 5

  Why do you rate yourself where you do?

- What is your content area knowledge regarding socio-scientific issues in the classroom?

  1 = Novice and 5 = Expert

  1 2 3 4 5

  Why do you rate yourself where you do?

- What is your pedagogical knowledge in the classroom?

  1 = Novice and 5 = Expert

  1 2 3 4 5

  Why do you rate yourself where you do?

- What is your technological pedagogical content knowledge in the classroom?

  1 = Novice and 5 = Expert

  1 2 3 4 5

  Why do you rate yourself where you do?

REFLECTION PAPER II - For performers

Each participant whose groups performed the microteaching in the classroom will write a reflection paper individually after their microteaching performance by answering the questions provided in the below table.

SSI TEACHING	TECHNOLOGY INTEGRATION
Teacher knowledge/Skills	
• How effective were you in emphasizing the scientific base of the issue? That is, how suitable were the activities to make students become aware that the issue caused by the advancement of science and/or technology? • How confident were you that you possess in-depth scientific knowledge involved in the socio-scientific issue? • How confident were you that you possess in-depth knowledge of argumentation and how to evaluate the quality of student arguments? • How confident were you that you possess in-depth knowledge of the instructional strategies suggested by the Turkish science curriculum?	• How effective were you in selecting technologies that includes scientifically correct content? • How effective were you in deciding technologies that are appropriate for student level? • How effective were you in selecting technologies that are appropriate for the socio-scientific issue? • How effective were you in utilizing technology to reveal students' prior knowledge regarding to target SSI? • How effective were you in utilizing technology to reveal and overcome students' misconceptions and learning difficulties? • How effective were you in utilizing technology to address social aspects?

- How confident were you that you were aware of the STSE, content and SPS objectives of the curriculum that you tried cover?
- How effective were you in linking the socio-scientific issue with the nature of science, if you mentioned NOS in your lesson plan?
- How effective were you in addressing the social (moral, ethical, etc.) issues related to the socio-scientific issue?
- How confident were you that you possess in-depth knowledge of moral and ethical development of your students and how to enhance such development?
- How effective were you in selecting developmentally (cognitive, affective) appropriate issue for students?
- How effective were you in considering students' possible misconceptions and learning difficulties while teaching SSI?
- How effective were you in considering the students' related pre-instructional knowledge for this SSI?

- How effective were you in utilizing technology to address nature of science aspects?
- How effective were you in deciding developmentally (cognitive, affective and psychomotor) appropriate technologies?
- How confident were you that you possess in-depth knowledge of the instructional technologies suggested by the Turkish science curriculum?
- Which curriculum objectives did you address in your instruction by using technology?
- How effective were you in addressing these objectives by using technology?

Teacher behavior

- How effective were you in managing the classroom while encouraging the classroom discourse?
- How effective were you in using instructional strategies to encourage classroom discourse?
- How aware were you whether your personal beliefs affect the flow of the discourse?
- How fair were you in considering students ideas that is different from what you believe personally? Remember, if you are using a true issue there is no single correct answer.
- How effective were you in following and addressing students' ideas throughout the lesson?
- Which criteria did you use when deciding whether particular student idea

- How effective were you in managing the classroom while integrating technology into teaching and learning process?
- How effective were you in using the technology in a way that facilitates your use of instructional strategy?
- How effective were you in giving clear directions to students about technology use?
- How effective were you in monitoring students' progress while they are working with technology?
- How effective were you in using technology to assess students' understanding?
- How effective were you in using technology to facilitate classroom

should be discussed in the classroom discourse?

- How effective did you evaluate students' evidences for their arguments?

discourse (collecting students' data, claims, conclusions etc.)?

Learning

- How effective were you in encouraging the students to find scientifically acceptable supporting evidences for their claims?
- How effective were you in encouraging students to be aware of the opposing claims?
- How effective was your instruction on student thinking skills?
- How effective were you in encouraging students to support their claims against the opposing claims?
- How effective did the SSI context you chose for the lesson address students' thinking skills? Which thinking skills did students put into action?
- How effective was the issue you chose for the lesson in contributing to students' science learning?
- How proper was the SSI context you chose for the lesson to contribute to scientific literacy of students?
- How effective were the technologies you used in the lesson in encouraging students' understanding of the SSI context?
- How effective were the technologies you utilized in the lesson in addressing students' thinking skills?
- What was the contribution of the technologies you have utilized in the lesson to improve students' scientific literacy?
- How effective were you in encouraging students to use technology to find scientific evidences for their claims and for the opposing claims?

Classroom environment

- How much were the SSI context you have chosen for the lesson convenient for active involvement of the students?
- How effective was the classroom environment to encourage students to reveal and support their ideas?
- How effective were you in choosing an SSI context suitable to draw a relationship between their daily life experiences and the targeted scientific knowledge?
- How effective were you in using technology to create your intended classroom environment?

Lesson plan

- How effective were you in addressing the objectives related to SSI as you indicated in your lesson plan?
- How effective were you in following your plan about technology usage?

- How congruent was your teaching with your lesson plan?
- How confident were you in making changes in your instruction that is planned ahead in your lesson plan?
- What would you do differently from this lesson plan if you were asked to revise you developed lesson plan?
- What kind of problems did you faced with while using technology?
- How confident were you in dealing with unexpected problems that occurred during technology use?
- How effectively did you manage time while integrating technology into teaching and learning process?
- Would you like to change the technology use whenever you are asked to teach the same SSI with technology? Why?

REFLECTION PAPER III

Each participant will write a reflection paper to evaluate the whole process followed in the lesson and their development in this process at the end of the semester.

1. How did the following parts of the lesson contribute to your understanding about Socioscientific Issues (SSI) teaching Technological Pedagogical Content Knowledge (TPACK)? Describe your TPACK development about SSI teaching in detail after you went through the each process.
    - introductory lectures,
    - observations of models,
    - lesson planning,
    - teaching performances,
    - writing reflections
2. What do you think about your improvements in the following components of technology integration knowledge?
    - knowledge of teaching strategy
    - knowledge of classroom management
    - knowledge of student learning
    - knowledge of curriculum
    - knowledge of assessment
3. What was the role of planning in your technology integration? Which points did you consider while planning your technology integrated SSI lesson?
4. How did you use technology in the planning process?
5. How did you feel in the technology integrated SSI lessons as teacher and as student?
6. What were the challenges you faced in the following processes? Explain how you coped with these challenges.
    - comprehending the foundations of TPACK
    - deciding the proper technology and integrating it into the teaching sequence

- deciding the instructional strategy
- deciding the socio-scientific issue
- planning the lesson
- performing teaching
- evaluating your teaching performance after teaching

Write about your thoughts on your TPACK

7. What does technological pedagogical content knowledge mean to you?
8. Draw a concept map to explain your understanding of TPACK.
9. Based on your understanding of TPACK, how can you rate yourself? Please assess your current knowledge domains by choosing the number that best represents where you believe you would align yourself.

1 = Novice and 5 = Expert

- What is your technology knowledge in the classroom?

  1 2 3 4 5

  Why do you rate yourself where you do?

- What is your content area knowledge regarding socio-scientific issues in the classroom?

  1 2 3 4 5

  Why do you rate yourself where you do?

- What is your pedagogical knowledge in the classroom?

  1 2 3 4 5

  Why do you rate yourself where you do?

- What is your technological pedagogical content knowledge in the classroom?

  1 2 3 4 5

  Why do you rate yourself where you do?

D. POSTLESSON STRUCTURED INTERVIEW QUESTIONS

SSI TEACHING

SSI topic (Case-based Issues)

1. Sunumunuzda ele aldığınız sosyobilimsel konu neydi?
2. Ele aldığınız sosyobilimsel konunun bilimsel temellerini vurgulamakta ne kadar etkiliydiniz?
    a. Kullandığınız aktiviteler öğrencilerin bu sosyobilimsel konunun bilim ve teknolojinin gelişiminden kaynaklandığını anlaması için ne kadar yardımcı oldu?
3. Anlattığınız sosyobilimsel konunun altında yatan bilimsel bilgiyle ilgili kendi bilginizden ne kadar emindiniz?
4. Bu ders için seçtiğiniz sosyobilimsel konu öğrencilerin
    a. Hangi düşünme bercerilerini geliştirdi? Düşünme becerilerini geliştirmede ne derece etkiliydi?
    b. Fen öğrenmesine katkı sağlama konusunda ne derece etkiliydi?
    c. Fen teknoloji toplum ve çevre ilişkilerini anlaması konusunda ne derece etkiliydi?
    d. Fen dersine karşı olumlu tutum geliştirmesi açısından ne derece etkiliydi?
    e. Bilim okuryazarlığına katkı sağlama konusunda ne derece etkiliydi?
    f. Ahlaki gelişimlerine katkı sağlama konusunda ne derece etkiliydi?
    g. Öğretmeyi hedeflediğiniz fen konusu ile günlük hayatları arasında ilişki kurmalarını sağlamada ne derece etkiliydi? (SSI günlük hayatıyla ne kadar ilişkiliydi?)
    h. Aktif katılımı için ne derece uygundu?

Argumentation (Discourse Issues)

5. Sunumunuzda hangi öğretim stratejilerini kullandınız?
6. Fen bilimleri öğretim programında önerilen öğretim stratejileri hakkındaki bilginizden ne derece emindiniz?
    a. Kullandığınız öğretim stratejisinin öğretim programıyla örtüşüp örtüşmediğinden ne derece emindiniz?
7. Argümantasyon ile ilgili ne biliyordunuz?
    a. Öğrencilerin argümanlarının kalitesini nasıl ölçeceğinizi biliyor muydunuz?
    b. Argümantasyon ile ilgili bildiklerinizden ne derece emindiniz?
8. Sınıfta bir yandan tartışmayı teşvik ederken bir yandan sınıfı yönetmekte ne derece başarılıydınız?

9. Sınıf tartışmasını teşvik edebilmek için hangi öğretim stratejilerini kullandın?
    a. Bu öğretim stratejileri tartışma ortamını nasıl teşvik etti?
    b. Tartışmayı teşvik edebilmek için öğretim stratejilerini ne derece etkili kullanabildiniz?
10. Ders boyunca öğrencilerin görüşlerini takip etmede ve yeri geldiğinde onlara değinmede ne derece etkiliydiniz?
11. Belli bir öğrenci düşüncesinin sınıf tartışmasında ele alınıp alınmaması gerektiğine karar verirken hangi kriterleri kullandınız?
12. Öğrencilerin argümanları için sundukları delilleri değerlendirmede ne derece etkiliydiniz?
13. Öğrencileri, argümanları için bilimsel olarak doğru, destekleyici deliller bulmaya teşvik etmede ne derece etkiliydiniz?
14. Öğrencilerin karşıt görüşlerin de farkında olması için nasıl bir strateji izlediniz?
    a. Öğrencilerin karşıt görüşlerin farkında olmasını teşvik etmede ne derece etkiliydiniz?
15. Öğrencileri kendi görüşlerini karşıt görüşlere karşı savunmasını teşvik etmede ne derece etkiliydiniz?
16. Sınıf ortamı öğrencilerin görüşlerini belirtmesi ve savunmasını teşvik etmek açısından ne derece etkiliydi?
17. Sizin bu sosyobilimsel konu hakkındaki görüşünüz neydi?
    a. Kendi düşüncenizi sınıfa ne zaman ve nasıl açıkladınız?
    b. Kendi düşüncelerinizin tartışmanın akışını değiştirip değiştirmediğinden ne derece emindiniz?
18. Sizden farklı düşünen öğrencilerin görüşlerini de göz önünde bulundurma konusunda ne derece adildiniz?

Nature of Science Issues

19. Ders anlatımınızda açık bir şekilde bilimin doğasından bahsettiniz mi?
20. Ders anlatımınızda yaptığınız aktivitelerle örtük bir şekilde bilimin doğasını anlamalarını sağladınız mı?
21. Ders anlatımınızda bilimin doğasından bahsettiyseniz, kullandığınız sosyo-bilimsel konuyu bilimin doğasıyla ilişkilendirmekte ne derece etkiliydiniz?
22. Öğrencilerin epistemolojik inançlarının ne derece farkındaydınız?
23. Öğrencilerin epistemolojik inançları ya da bilimin doğası ile ilgili inançlarının karar verme süreçlerini etkileyip etkilemediğinin ne derece farkındaydınız?
24. Öğrenciler karşıt görüştekilerin delillerini kabul ederken hangi kriterleri göz önünde bulundurdular?
    a. Karşı grupların ikna edicilikleri mi yoksa bilimsel doğrulukları mı karar verme süreçlerinde daha etkiliydi?
    b. Öğrenciler hangi özelliklere sahip delilleri doğru kabul ederken hangi özelliklere sahip delilleri doğru kabul etmediler?

Student background (Cultural Issues)

25. Öğrencilerin ahlaki ve etik açıdan hazırbulunuşlukları hakkında ne biliyordunuz?
    a. Öğrenciler deliller ortaya koyarken ya da karşıt görüştekilerin delillerini değerlendirirken toplumsal ya da kişisel değerler ne derece etkiliydi?
    b. Dini inançları ne derece etkiliydi?
    c. Yaşadıkları coğrafi bölge ne derece etkiliydi?
    d. Öğrencileri ahlaki yönde nasıl geliştireceğiniz hakkındaki bilginizden ne derece emindiniz?
26. Seçtiğiniz konu öğrencilerin bilişsel gelişimi için ne derece uygundu?
    a. Seçtiğiniz konu öğrencilerin duyuşsal gelişimi için ne derece uygundu?
    b. Öğrencilerin gelişimsel düzeylerine uygun bir konu seçmekte ne derece etkiliydiniz?
27. Öğrencilerin muhtemel kavram yanılgılarını veya öğrenme zorluklarını göz önünde bulundurdunuz mu?
    a. Öğrencilerin kavram yanılgılarını gidermekte ne derece başarılıydınız?
    b. Bunun için neler yaptınız?
    c. Bu yaptıklarınız öğrencinin kavram yanılgısını nasıl giderebildi?
28. Öğrencilerin sosyobilimsel konu ile ilgili önbilgilerini göz önünde bulundurdunuz mu?
    a. Konuyla ilgili neleri bildiklerini ya da neleri bilmediklerini düşünüyordunuz?
    b. Öğrencilerin önbilgilerini ele almada ne derece başarılıydınız?

Curriculum and Lesson Plan

29. Anlattığınız dersle hangi kazanımlara ulaşmayı hedefliyordunuz?
30. Ders anlatımlarınızda ele aldığınız kazanımların öğretim programında bahsedilen FTTÇ, bilgi, beceri (bilimsel süreç becerileri, analitik düşünme, karar verme, yaratıcı düşünme, girişimcilik, iletişim, takım çalışması) ve duyuş öğrenme alanlarıyla örtüşüp örtüşmediğinden ne derece emindiniz?
31. Ders planınızda bahsettiğiniz sosyobilimsel konular ile ilgili kazanımlara ulaşmada ne derece etkiliydiniz?
32. Ders anlatımınız ders planınızla ne derece örtüşüyordu?
33. Anlatımınız esnasında ders planınızda ani değişiklikler yapmaya karar verdiğiniz durumlar oldu mu?
    a. Neden değişiklik yapma ihtiyacı duydunuz?
    b. Bu değişikliklere nasıl karar verdiniz?

c. Ders anlatımınız esnasında daha önce ders planınızda yazdıklarınızda değişiklikler yaparken kendinizden ne derece emin olarak değişiklik yaptınız?
d. Yaptığınız değişikliğin işe yaradığını düşünüyor musunuz?

34. Bu ders planınızda değişiklik yapmanız istenseydi ne gibi değişiklikler yapardınız?

TECHNOLOGY INTEGRATION

Overarching conception about the purposes for incorporating technology in effective SSI teaching.

1. Bir SSI konusu ele alırken sınıfta teknoloji kullanımının yeri ve önemi hakkında ne düşünüyorsunuz?
2. Ele aldığınız SSI konusunu teknoloji kullanmadan da anlatmanız mümkün müydü?
    a. Teknoloji kullanmadığınız durumlarda ne gibi farklılıklar olurdu?

Knowledge of students' understandings, thinking, and learning in SSI topics with technology

3. Öğrencilerin düzeyine uygun teknolojiler seçmekte ne derece etkiliydiniz?
    a. Öğrencilerin bilişsel düzeyine uygun teknolojiler seçmekte ne derece etkiliydiniz?
    b. Öğrencilerin duyuşsal düzeyine uygun teknolojiler seçmekte ne derece etkiliydiniz?
    c. Öğrencilerin kullandıkları teknolojiler psikomotor becerilerini kullanmayı gerektiriyor muydu? Bu tarz teknolojiler neler olabilir?
4. Teknolojiyi öğrencilerin ele aldığınız SSI ile ilgili önbilgilerini ortaya çıkarmak için nasıl kullandınız?
    a. Kullandığınız teknoloji önbilgileri nasıl ortaya çıkardı?
    b. Önbilgilerini ortaya çıkarırken teknoloji kullanmada ne derece etkiliydiniz?
5. Teknolojiyi öğrencilerin kavram yanılgılarını ve öğrenme zorluklarını ortaya çıkarmak ve gidermek için nasıl kullandınız?
    a. Kullandığınız teknoloji kavram yanılgılarını nasıl ortaya çıkardı?
    b. Kullandığınız teknoloji kavram yanılgılarını nasıl giderdi?
    c. Öğrencilerin kavram yanılgılarını ve öğrenme zorluklarını ortaya çıkarır ve giderirken teknoloji kullanmada ne derece etkiliydiniz?
6. Derste kullandığınız teknolojiler öğrencilerin hangi düşünme becerilerini geliştirdi?
    a. Bu düşünme becerilerine nasıl bir katkıda bulundu?
    b. Teknoloji kullanarak öğrencilerin düşünme becerilerini geliştirme konusunda ne derece etkiliydiniz?

7. Öğrencilerin bilim ve teknoloji okuryazarlığı, öğretim etkinlikleri sırasında teknoloji kullanmalarını ve öğrenme etkinliklerinden faydalanma düzeylerini nasıl etkiledi?
8. Derste kullandığınız teknolojiler, öğrencilerin bilimsel ve teknolojik okuryazarlığının gelişimine nasıl bir katkıda bulundu?
9. Teknoloji kullanımının tutum değer inançlarına etkisi nasıl oldu?

Knowledge of curriculum and curricular materials that integrate technology in effective SSI teaching

10. Ders anlatımınızda SSI konusunu ele alırken hangi teknolojilerden faydalandınız?
11. Seçtiğiniz teknolojiler bilimsel bir bilgi içeriyor muydu?
    a. Bilimsel olarak doğru içeriğe sahip teknolojiler seçmekte ne derece etkiliydiniz?
12. Ele aldığınız sosyo-bilimsel konuya uygun teknolojileri nasıl seçtiniz?
    a. Derste kullandığınız teknolojiler öğrencilerin sosyobilimsel konuyu anlamasını sağlamada ne derece etkiliydi?
13. Teknolojiyi öğretim programının farklı öğrenme alanlarındaki hangi kazanımlara ulaşmak için kullandınız?
    a. Bu kazanımlara ulaşmak için teknolojiyi ne derece etkili kullandınız?
14. Sosyobilimsel konunun toplum üzerindeki etkisini ele almak için hangi teknolojileri ve nasıl kullandınız?
    a. Teknolojiyi sosyobilimsel konunun toplum üzerindeki etkisini ele almak için ne derece etkili kullandınız?
15. Teknolojiyi bilimin doğasını vurgulamak için kullandınız mı?
    a. Teknolojiyi bilimin doğasını vurgulamak için ne derece etkili kullandınız?

Knowledge of instructional strategies and representations for effective SSI teaching with technologies

16. İstediğiniz sınıf ortamını oluşturabilmek için teknolojiyi kullanmada ne derece etkiliydiniz?
    a. Öğrenciler teknoloji kullanırkenki sınıf ortamını anlatabilir misiniz?
    b. Öğrenciler teknoloji kullanırken sınıf yönetimini nasıl sağladınız?
17. Teknolojiyi öğrenme ve öğretme sürecine nasıl entegre ettiniz?
18. Teknolojiyi belirlediğiniz öğretim stratejisine nasıl entegre ettiniz? Önce hangisine karar verdiniz?
    a. Kullandığınız teknolojiler öğretim stratejinizi nasıl etkiledi?
    b. Teknolojiyi öğretim stratejinize entegre etmekte ne derece etkiliydiniz?

19. Öğretim stratejisinin uygulanmasında teknolojiyi aktif katılım sağlamak için nasıl kullandınız?
20. Öğrenciler teknolojiyi aşağıda bahsedilen aşamalarda nasıl kullandı?
    a. İddia (claim) oluşturmak
    b. Veri toplamak
    c. İddialarını savunmak için delil bulmak
    d. Karşıt görüşleri çürütmek için delil bulmak
    e. Sonuca ulaşmak
    f. Teknoloji bu süreçleri nasıl etkiledi?
    g. Bu süreçlerde teknolojiyi ne derece etkili kullandınız?
21. Öğrencilere teknoloji kullanımlarıyla ilgili nasıl yönergeler verdiniz?
    a. Verdiğiniz yönergeler açık ve anlaşılır mıydı?
    b. Öğrencilere teknoloji kullanma konusunda açık yönergeler vermede ne derece etkiliydiniz?
22. Teknoloji kullanımıyla ilgili planınızı takip etmede ne derece etkiliydiniz?
23. Teknolojiyi kullanırken ne gibi sorunlarla karşılaştınız?
24. Teknoloji kullanımınız sırasında ortaya çıkan beklenmedik problemleri nasıl çözdünüz?
    a. Beklenmedik problemleri çözme konusunda kendinizden ne derece emindiniz?
25. Teknolojiyi öğrenme ve öğretme sürecine entegre ederken zamanı nasıl kontrol ettiniz?
    a. Zamanı kontrol etmede ne derece etkiliydiniz?

Knowledge of Assessment with Technology in Effective SSI Teaching

26. Öğrenciler teknoloji kullanarak çalışmalarını yürütürken gelişimlerini nasıl takip ettiniz?
    a. Öğrencilerin gelişimlerini izlemede ne derece etkiliydiniz?
27. Öğrencilerin farklı öğrenme alanlarındaki gelişimlerini ölçme ve değerlendirmede teknolojiden nasıl faydalandınız?
    a. Ne derece etkiliydiniz?
28. Farklı amaçlara (formative, summative, diagnostic) yönelik değerlendirme yaparken teknolojileri nasıl kullandınız?
29. Aynı sosyobilimsel konuyu teknolojiyle öğretmeniz istense, kullandığınız teknolojilerde değişiklik yapar mıydınız? Neden?
30. Teknolojiyi kullanarak SSI anlatacak birine ne gibi önerilerde bulunurdunuz?

E. APPROVAL OF ETHIC COMMITE METU RESEARCH CENTER

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

DUMLUPINAR BULVARI 06800
ÇANKAYA ANKARA/TURKEY
T: +90 312 210 22 91
F: +90 312 210 79 59
ueam@metu.edu.tr
www.ueam.metu.edu.tr

Sayı: 28620816 / 361

13 EKİM 2015

Gönderilen: Prof. Dr. Özgül Yılmaz TÜZÜN

İlköğretim

Gönderen: Prof. Dr. Canan SÜMER

İnsan Araştırmaları Komisyonu Başkanı

İlgi: Etik Onayı

Danışmanlığını yapmış olduğunuz Doktora Öğrencisi Meltem IRMAK "Fen Bilgisi Öğretmen Adaylarının Sosyo-Bilimsel Konular Hakkındaki Teknolojik Pedagojik Alan Bilgilerini Üstbilişsel Yaklaşımla Geliştirme" isimli araştırması İnsan Araştırmaları Komisyonu tarafından uygun görülerek gerekli onay 13.10.2015-22.01.2016 tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Canan SÜMER

Uygulamalı Etik Araştırma Merkezi

İnsan Araştırmaları Komisyonu Başkanı

F. CURRICULUM VITAE

PERSONAL INFORMATION

Name : Meltem Irmak

Date of birth : 30.07.1987 / Eskişehir

Nationality : Türkiye

E-mail : meltemsavas@gmail.com

EDUCATION

2011- 2018 **Ph. D.:** Middle East Technical University/Ankara-Turkey - Elementary Education (GPA: 3.86 / 4.00)

2009 – 2011 **M. Sc.:** Middle East Technical University / Ankara-Turkey Elementary Science and Mathematics Education (GPA: 3.80 / 4.00)

2004-2009 **B. Sc. Major:** Middle East Technical University / Ankara-Turkey Elementary Science Education (GPA: 3.47 / 4.00)

2007-2009 **B. Sc. Minor:** Middle East Technical University / Ankara-Turkey - Biology (GPA: 3.13 / 4.00)

EXPERIENCE

09.2009 – 11.2009 **Science and Mathematics Teacher** - Yavuz Sultan Selim Elementary School

12.2009 – 10.2011 **Research Assistant -** Middle East Technical University / Elementary Science Education Department

10.2011 – **Research Assistant** - Gazi University / Elementary Science Education Department

PROJECTS

01.2011-12.2011 **Researcher** - "Investigating Pre-service Science Teachers' Technological Pedagogical Content Knowledge Regarding Genetics" METU-BAP Coordination BAP- 07-03-2011-104

09.2013-08.2015 **Scholar** – "Ortaöğretim Fizik Öğretim Programı İle Bütünleşik, Etkileşimli Bilgisayar Animasyon, Simülasyon Ve Öğrenme Ortamları İçeren Modüller Hazırlanarak, Hizmet-İçi Eğitimler Yoluyla Yaygınlaştırılıp Eğitim Sürecine Uyumunun Sağlanması ve Öğretmenlerin Teknolojik Pedagojik Alan Bilgilerinin Geliştirilmesi" TUBİTAK (The Scientific and Technological Research Council of Turkey) Project No:110K558

THESIS

September, 2011 Investigating Pre-service Science Teachers' Technological Pedagogical Content Knowledge Regarding Genetics – Master Thesis (Supervisor: Assoc. Prof. Dr. Özgül YILMAZ-TÜZÜN)

PUBLICATIONS

International Journal Papers

Elmas, R., Öztürk, N., Irmak, M., & Cobern, W. W. (2014). An Investigation of Teacher Response to National Science Curriculum Reforms in Turkey. *Eurasian Journal of Physics and Chemistry Education, 6*(2-33).

International Conference Papers

Ozturk, N., Elmas, R., & Savas, M. (2011). Private School Elementary Teachers' Reflections on New Science and Technology Curriculum. *Proceedings of the Second International Conference on New Trends in Education and Their Implications (ICONTE),* 509-516.

Savas, M., Elmas, R., & Ozturk, N. (2012). A Curriculum Reflection: New Science and Technology Curriculum in Turkey, In C. Bruguière, A. Tiberghien & P. Clément (Eds.), E-Book Proceedings of the ESERA 2011 Conference: Science learning and Citizenship. Part 9 (Dolin, J. & Rannikmae, M.), (pp. 62-68) Lyon, France: European Science Education Research Association. ISBN: 978-9963-700-44-8

Savas, M., Yılmaz-Tüzün, O. (2012, March). *Investigating Pre-service Science Teachers' Content Knowledge And Perceived TPACK Regarding Genetics*. Paper presented at the meeting of National Association of Research in Science Teaching (NARST) Indianapolis, IL, USA.

Inaltun, H., Irmak, M., Yanış, H., & Ercan, J. (2013, February). *Investigating differences in preservice science teachers' resource management strategies in preparing laboratory report.* Paper presented at the meeting of World Conference on Educational Sciences, Roma, Italy.

Ercan, J., Yanış, M., & Irmak, M. (2013, April). *Science writing heuristic: An inquiry-based laboratory approach to promote science achievement in general chemistry laboratory.* Paper presented at the meeting of National Association of Research in Science Teaching (NARST) Rio Grande, Porto Rico, USA.

Irmak, M., Yanış, H., & Ercan, J. (2014, April*). Investigating the effect of science writing heuristic laboratory report format on critical thinking.* Paper presented at the meeting of National Association of Research in Science Teaching (NARST) Pittsburgh, PA, USA.

Taşar, M. F., İngeç, Ş. K., Timur, B., Şen, A. İ., Uşak, M., Şentürk, M. L., Yılmaz, D., Ercan, J., & Irmak, M. (2014). *A virtual online physics learning environment (VOPLE) closely aligned with curriculum outcomes.* Paper presented at the meeting of ISER World Conference, Nevşehir, Turkey.

Şentürk, M. L., Taşar, M. F., Yılmaz, D., Ercan, J., Irmak, M. (2014). *Fostering physics teachers' development of TPACK through a professional development program.* Paper presented at the meeting of ISER World Conference, Nevşehir, Turkey.

Ercan, J., Yılmaz, D., Senturk, M. L., Irmak, M. & Tasar, M. F. (2015). *Examining a teacher's integration of animations and simulations in physics teaching after professional development program.* Paper presented at the meeting of AERA, Chicago, USA

Taşar, M. F., Ercan, J., Şentürk, M. L., Yılmaz, D., & Irmak, M. (2015). P*hysics teachers' development of technology, pedagogy and content knowledge: a mixed method study*. Paper presented at the meeting of ISER World Conference, Istanbul, Turkey

Taşar, M. F., Şentürk, M. L., Yılmaz, D., Ercan, J., Irmak, M., & Uşak, M. (2015). *The VOPLE Project.* Paper presented at the meeting of ISER World Conference, Istanbul, Turkey

Irmak, M., Yılmaz, D., Ercan, J., Senturk, M. L., & Tasar, M. F. (2015). *Changes in physics teachers' cognitive structures about using educational animations and simulations.* Paper presented at ESERA, Helsinki, Finland.

Irmak, M., Yılmaz, D., Ercan, J., Senturk, M. L., & Tasar, M. F. (2016). Changes in physics teachers' cognitive structures about using educational animations and simulations. In J. Lavonen, K. Juuti, J. Lampiselkä, A. Uitto & K. Hahl (Eds.), *Electronic Proceedings of the ESERA 2015 Conference. Science education research: Engaging learners for a sustainable future*, Part 14 (co-ed. Berry, A., & Couso, D.), (pp. 2445-2451). Helsinki, Finland: University of Helsinki. ISBN 978-951-51-1541-6

Şentürk, M. L., Irmak, M., Ercan, J., Yılmaz, D., & Taşar, M. F. (2016). Examining physics teachers' technological pedagogical content knowledge after a professional development program: multiple case study. Paper presented at the meeting of National Association of Research in Science Teaching (NARST) Baltimore, USA.

National Conference Papers

Savaş, M., Öztürk, N. and Yılmaz-Tüzün, Ö. (2010, June). *Fen bilgisi öğretmen adaylarının fen eğitiminde teknoloji kullanımı ile ilgili görüşleri ile ilişkili olan* *faktörlerin belirlenmesi*. Paper presented at IX. National Congress of Science and Mathematics Education, Izmir, Turkey.

Savaş, M., Öztürk, N. and Yılmaz-Tüzün, Ö. (2010, September). *Fen bilgisi öğretmen adaylarının teknolojik pedagojik alan bilgisinin incelenmesi.* Paper presented at IX. National Congress of Science and Mathematics Education, Izmir, Turkey.

Irmak, M., & Yanış, H., (2012, June). *Yetişkinlerin habitat parçalanması sorununa ilişkin sonuç algılarının çevresel değerler açısından incelenmesi*. Paper presented at X. National Congress of Science and Mathematics Education, Niğde, Turkey.

Irmak, M. (2012, September). *Education for sustainable development experiences for teachers, How do dams affect our life?.* Activity presented as workshop activity at the meeting of Applied Education Congress, METU, Ankara, Turkey.

Inaltun, H., Irmak, M., Ercan, J. Yanış, H., & Yürük, N. (2014). *Fen bilgisi öğretmen adaylarının iş güç enerji konusunda sahip oldukları alternatif kavramların belirlenmesi.* Paper presented at XI. National Congress of Science and Mathematics Education, Adana, Turkey.

Yanış, H., Ercan-Dursun, J., Irmak, M., İnaltun, H., & Yürük, N. (2016). *Üç-aşamalı tanılayıcı test geliştirme: İş, güç ve enerji konusu*. Paper presented at XII. National Congress of Science and Mathematics Education, Trabzon, Turkey.

SCHOLARSHIPS AND AWARDS

2014 **International Conference Attendance Scholarship**

TÜBİTAK-2224 The Scientific And Technological Research Council of Turkey-International Conference Scholarship for conference held in Pittsburg, USA

2012 **METU Thesis of the Year**

METU Institute of Social Sciences- Best Master Thesis on Elementary Science and Mathematics Education Program -

Investigating Pre-service Science Teachers' Technological Pedagogical Content Knowledge Regarding Genetics

Doctoral Student Scholarship

TÜBİTAK- 2211, The Scientific And Technological Research Council of Turkey- Graduate Scholarship Programme

Conference Scholarship

NARST International Committee Scholarship for conference held in Indianapolis, USA

2011	**International Conference Attendance Scholarship** TÜBİTAK-2224, The Scientific and Technological Research Council of Turkey-International Conference Scholarship for conference held in Lyon, France
2009	**Graduate Student Scholarship** TÜBİTAK-2228, The Scientific and Technological Research Council of Turkey-Graduate Scholarship Programme
2007, 2008, 2009	**High Honor Undergraduate Student** Middle East Technical University by Prof. Dr. Ural AKBULUT, METU Rector
2006, 2007	**Honor Undergraduate Student** Middle East Technical University by Prof. Dr. Ural AKBULUT, METU Rector

RESEARCH AREAS

Technological Pedagogical Content Knowledge, Curriculum Change, Metacognition, Socioscientific Issues, Conceptual Change

G. TURKISH SUMMARY / TÜRKÇE ÖZET

ETKİLİ SOSYOBİLİMSEL KONULAR ÖĞRETİMİ PRATİKLERİNİN EĞİTİM TASARIM ARAŞTIRMASI İLE GELİŞTİRİLMESİ

1. Giriş

Fen eğitiminin nihai hedefi, bilim okuryazarı vatandaşlar yetiştirmektir. Son yıllarda, sosyo-bilimsel konular (SBK) aracılığı ile yapılan öğretimin bilim okur-yazarlığına katkısı uluslararası fen eğitimi camiası ve ulusal eğitim politikası oluşturucuları tarafından kabul edilmiştir. (MoNE, 2013; Zeidler & Keefer, 2003; Zeidler & Nichols, 2009; Zeidler, Sadler, Simmons, & Howes, 2005). Son yıllardaki araştırmalar, sosyo-bilimsel konuların fen eğitiminde bir bağlam olarak kullanılmasının önemini vurgulamakta ve öğrencilerin konu bilgisini geliştirmenin yanında, kritik düşünme, kanıta dayalı karar verme, yansıtıcı yargılama, argumantasyon ve etik uslamlama yeteneğini geliştirdiğini vurgulamaktadır. (Klosterman & Sadler, 2010; Zeidler, Sadler, Applebaum, & Callahan, 2009). Öğrenciler SBK bağlamında fen öğrenirken, hem kişisel hem de sosyal bilgi yapılandırmasında aktif olarak yer alabilirler.

Sosyo-bilimsel konularının öğretiminin çok yönlü sonuçlarına ek olarak, belirli bir bilimsel ilkenin öğretimiyle karşılaştırıldığında bazı zorlukları bulunmaktadır. Öğretmenler standart fen öğretim programını uygulama bilgi ve becerisine sahip olmakla birlikte, sosyo-bilimsel konulara dayalı bir programın uygulanması için gerekli olan pedagojik uygulamalar öğretmenler için nispeten yenidir(Zeidler et al., 2009). Sosyo-bilimsel konuların öğretimi, geleneksel konu öğretimine ve değerlerden uzak fen eğitimine dayalı olan yaklaşımdan, sosyokültürel bakış açısını yansıtan bir fen eğitimi yaklaşımına geçmeyi gerekli kılar (Tal & Kedmi, 2006). Bu da, öğrencilerin argumantasyon becerilerini, konuların kompleks yapılarını kavrayabilmelerini, ve verilerin güvenirliği konusunda bir farkındalığı gerekli kılar (Zeidler & Nichols, 2009). öğretmenler Fen eğitimini sosyo-bilimsel konular bağlamında sosyal yapılandırmacı yaklaşımla öğretmek için bireylerin ve grupların bilgiyi yapılandırabilmeleri için iletişim kurmalarına ve işbirliği yapmalarına izin vermelidir (Tal & Kedmi, 2006). Bu sebeple, sosyo-bilimsel konuların öğretimi sırasında öğretmenler bazı zorluklarla karşılaşmaktadır. Ancak, teknolojinin sosyo-bilimsel konuların öğretimine entegre edilmesi, bu nispeten yeni ve zorlayıcı olan işlerin hafifletilmesinde öğretmene yardımcı olabilecektir.

Çalışmalar çeşitli teknoloji kullanımı sayesinde sosyobilimsel konuların öğretiminin öğrencilerin motivasyonunu, katılımlarını ve öğrenmelerini arttırdığını göstermiştir (Belland, Gu, Armbrust, & Cook, 2015; Chang, Wu, & Hsu, 2013; Klosterman & Sadler, 2008). Bu sebeple, teknoloji ile desteklenen sosyal yapılandırmacı bir öğrenme ortamının sosyo-bilimsel konuların öğretiminin etkinliğini arttırdığı varsayılmaktadır. Sosyo-bilimsel konuların öğretiminde teknoloji kullanımının avantajları olsa da, öğretmenleri endişelendirebilecek bazı zorlukları da bulunmaktadır. Mesela, web-tabanlı sosyo-bilimsel konuların öğretimi öğretmenlerin çeşitli perspektifleri yansıtan güvenilir veri kaynakları bulmaları için daha fazla zaman harcamalarına sebep olabilir, çünkü öğretmenler öğrencilerin çeşitli verileri nasıl ele almaları gerektiği ve çeşitli iddalar ile verilerin geçerliliğini nasıl değerlendirecekleri konusunda sorumludur. (Zeidler & Nichols, 2009). Öğretmenler hem öğrencilerin bilgi iletişim teknolojileri ile çalışma süreçlerini desteklemeli hem de onların bu ortamlarda SBKları anlamlandırmalarına gerektiğinde müdahele etmelidir (Furberg & Ludvigsen, 2008). Öğretmen öğrencilerin konuşmalarını ve etkinliklerini takip edebilmelidir. Ratcliffe ve Grace'in (2003) öngördüğü gibi bugünün öğrencilerinin, çeşitli bilgi kaynaklarına erişimleri arttığından, öğretmenler eksik ve yanlı medya bilgileriyle baş edebilmelidir. Bu nedenle bu çalışmada etkili SBK öğretimi gerçekleştirebilmek için fen bilgisi öğretmen adaylarının (FBÖA) teknoloji entegrasyonu bilgileri geliştirilmeye karar verilmiştir.

Son on yılda, araştırmacılar, teknoloji entegrasyon bilgisi üzerine teorik perspektif geliştirmek için sistematik araştırma çalışmaları yürütmüş ve Shulman'ın (1987) Pedagojik Alan Bilgisi çerçevesi üzerine kurulmuş Teknolojik Pedagojik Alan Bilgisini (TPAB) açıklamışlardır. Pedagojik Alan Bilgisi teknoloji bilgisi eklenerek teknolojik pedagojik alan bilgisine genişletilmiştir. Ortaya çıkan çerçeve, öğretmenlerin içerik öğretimi etkinliğini arttırmak için öğretmenlerin teknoloji entegrasyonu ile ilgili bilişleri hakkında arştırmacılara değerli bilgiler sağlamıştır. Bu sebeple, FBÖA'nın teknoloji ile etkili SBK öğretimini incelemek için TPAB teorik çerçevesi kullanılmıştır.

Öğretmen adaylarının ve öğretmenlerin TPAB gelişimleri için düzenlenen eğitimlerde üstbilişin aktif hale getirilmesinin etkili olduğu bulunmuştur (Doering, Veletsianos, Scharber, & Miller, 2009; Kramarski & Michalsky, 2010). Doering vd'lerinin (2009) yaptığı çalışmada öğretmenleri TPAB ile ilgili açıkça düşündürmenin onları öğretimlerinin güçlü yönleri ve gelişimleri hakkında üstbilişsel düşünmeleri konusunda cesaretlendirdiğini göstermiştir. Dahası, Kramarski ve Michalsky (2010) öğretmen adaylarınn teknoloji, içerik ve pedagoji ile ilgili açıkça öğretim görmelerinin TPAB gelişimi için önemli olduğunu yaptıkları çalışmada desteklemişlerdir.

SBK'nın öğretimi, doğası gereği öğretmenler için zordur çünkü SBK konularının diğer fen kavramlarına kıyasla karmaşık bir doğası vardır. (Ratcliffe & Grace, 2003). Teknolojiyi SBK öğretimine entegre etmek, öğretmenlerin SBK'nın doğasını, ilgili pedagoji ve teknoloji hakkında dikkatli karar vermelerini gerektirir. Bu nedenle, öğretmenlerin SBK öğretimlerinin etkinliğini arttırmak için öğretim sürecinden önce, öğretim sürecinde ve öğretim sürecinden sonra teknolojiyi SBK öğretimine entegre etme yollarıyla ilgili sistematik düşünmelidirler. Üstbiliş, öğretmen adaylarının ve öğretmenlerin TPAB gelişimi ve etkili SBK öğretimi için önemli rol oynadığından, fen bilgisi öğretmen adaylarının teknoloji ile SBK öğretimleri sırasında öğretimleri ile ilgili üstbilişlerinin aktif olması gereklidir.

Bu çalışmanın başlıca amacı FBÖA'nın SBK öğretimi ile ilgili üstbilişlerini aktive ederek teknoloji ile etkili SBK öğretimlerini geliştirmektir. Bu amaça, bir devlet üniversitesinde fen bilgisi öğretmenliği lisans programında verilen bir dersin Eğitim Tasarım Araştırması (ETA) aracılığıyla yeniden dizayn edilmesiyle ulaşılmaya çalışılmıştır. Bu sebeple, çalışmanın iki temel amacı:

1. SBK öğretimini içeren bir lisans dersinde üstbilişi aktive ederek fen bilgisi öğretmen adaylarının teknoloji ile etkili SBK öğretimlerini geliştirmek.
2. Üstbililişi aktive ederek fen bilgisi öğretmen adaylarının teknoloji ile SBK öğretim pratiklerini geliştirmek amacı ile SBK öğretimini içeren bir lisans dersinin tasarım ilkelerini ve prensiplerini belirlemek.

Bu doktora tez çalışmasının belirtilen iki amacına ulaşmak için en uygun metodolojik yaklaşımın ETA olduğu düşünülmüştür. Her aşamanın Nieven ve Folmer (2013) ETA kalite kriterlerine göre yazılmış kendine ait araştıma sorusu bulunmaktadır. Bu kriterler arasında mantıksal bir hiyerarşi vardır ve tasarım araştırmasının farklı aşamalarında farklı kriterler vurgulanmaktadır

Bu çalışmanın genel araştırma sorusu:

- Fen bilgisi öğretmen adaylarının üst bilişlerinin aktive edilerek teknoloji ile etkili SBK öğretim pratiklerini geliştirmek için oluşturulan bir lisans dersinin özellikleri nedir?

Birinci fazda yer alan araştırma sorularının geliştirilmesinde uygunluk ölçüt olarak düşünülmüştür. Bu amaçla, birinci faz için aşağıdaki iki araştırma sorusu yazılmıştır:

1. Etkili SBK öğretimi, TPACK ve öğretmen üstbilişinin pedagojisi araştırmacılar tarafından nasıl işlevsel olarak tanımlanmıştır?

    a. Etkin SBK öğretiminin pedagojisini açıklayan teorik perspektifler nelerdir?
    b. Teknoloji entegrasyonunun etkili SBK eğitiminde rolü nedir?

    c. (Fen Bilimleri) öğretmenlerin TPAB'ini tanımlayan mevcut kavramsal çerçeveler nelerdir?

d. Öğretmenin üst bilişini tanımlayan mevcut kavramsal çerçeveler nelerdir?

2. Fen bilgisi öğretmen adaylarının, üst bilişini aktive ederek teknolojiyle etkili SBK öğretim uygulamalarını geliştirmeye yönelik bir dersin özellikleri nelerdir?
   a. Fen bilgisi öğretmen adaylarının teknoloji ile etkili SBK öğretim uygulamaları nasıl geliştirilebilir?
   b. Fen bilgisi öğretmen adaylarının üst bilişi nasıl etkinleştirilebilir?

Çalışmanın ikinci fazının amacı, fen bilgisi öğretmen adaylarının üstbilişlerini aktive ederek teknolojiyle etkin SBK öğretim uygulamalarını geliştirmenin etkili yollarını bulmaktır. Bu nedenle, bir sonraki araştırma sorusu için *tutarlılık* kriteri dikkate alınmıştır ve bu amaçla aşağıdaki araştırma sorusu geliştirilmiştir.

3. Üst bilişlerinin aktive edilmesiyle fen bilgisi öğretmen adaylarının etkili SBK öğretim uygulamalarını geliştirmek için oluşturulan dersin tasarımı tasarım prensipleri ile ne kadar tutarlıdır?

Çalışmanın *uygulanabilirliği* aşağıdaki araştırma sorusu ile ele alınmıştır.

4. Yeniden tasarlanan ders, üst bilişleri aktive edilerek fen bilgisi öğretmen adaylarının teknoloji ile etkili SBK eğitim uygulamalarını geliştirmeye ne kadar uygundur?

Son araştırma sorusu uygulamalarla ilgilidir. Bir ders uygulamaya konulduğunda, uygulamanın beklenen sonuçlara ulaşmada ne derece etkili olduğunun belirlenmesi büyük önem taşımaktadır. Bu nedenle, son araştırma sorusu, yeniden tasarlanmış dersin *etkinliğini* değerlendirmek için oluşturulmuştur:

5. Fen bilgisi öğretmen adaylarının, üst bilişini aktive ederek teknolojiyle etkili SBK eğitim uygulamalarını geliştirmede yeniden tasarlanmış ders ne kadar etkilidir?

a. Fen bilgisi öğretmen adaylarının etkili SBK eğitim uygulamalarının ders boyunca gelişimi nedir?

b. Yeniden tasarlanan derse katıldıktan sonra fen bilgisi öğretmen adaylarının SBK öğretim uygulamalarının doğası nedir?

c. Fen bilgisi öğretmen adaylarının teknoloji ile SBK öğretim uygulamalarına yönelik üst bilişlerinin yapısı nedir?

d. Fen bilgisi öğretmen adaylarının teknoloji ile etkili SBK öğretim uygulamaları ve üstbiliş yapıları arasındaki ilişki nedir?

e. Fen bilgisi öğretmen adaylarının etkili SBK eğitim uygulamalarının geliştirilmesinde yeniden tasarlanmış dersin katkısı nedir?

2. Literatür

Bu çalışmada literatür taraması iki aşamada yapılmıştır. Ilk aşamada yapılan literatür taraması sonucunda araştırmanın teorik çerçevesi oluşturulmuştur. Ikinci aşamada yapılan taramayla ise FBÖA'nın teknoloji ile etkili SBK öğretim pratiklerini geliştirebilecek dersin yeniden tasarımını yönlendiren tasarım prensipleri belirlenmiştir.

Sosyal yapılandırmacı öğrenme ortamının özellikleri TPAB geliştirmek ve üstbilişi etkinleştirmek için literatürde belirtilen öneriler göz önünde bulundurularak aşağıdaki tasarım prensipleri oluşturulmuştur.

- Tasarım Prensibi 1 (TP1): Öğrenmek ve öğretmek için uygun ve anlamlı SBKlar seçmede FBÖA'lara rehberlik edilmelidir.
- Tasarım Prensibi 2 (TP2): Öğrencilerin bilimin doğası inançlarını da içeren epistemolojik görüşlerinin SBK'da karar verme süreçlerindeki rolünü göz önünde bulundurmada FBÖA'na rehberlik edilmelidir.

- Tasarım Prensibi 3 (TP3): Söylem aracılığıyla paylaşılan sosyal bilgilerin yapılandırılmasına olanak sağlayan öğrenme ortamları oluşturmada FBÖA'na rehberlik edilmelidir.
- Tasarım Prensibi 4 (TP4): Farklı gelişimsel becerilere, kültürel geçmişe ve cinsiyete sahip farklı öğrenme gruplarının sunduğu fırsatları tanımak, kabul etmek ve onları en üst düzeye çıkarmak için FBÖA'na rehberlik edilmelidir.
- Tasarım Prensibi 5 (TP5): SBK'ın öğretiminin pedagojisi ve teknoloji entegrasyonu ile ilgili kavramlar ve teoriler açıkça tartışılmalıdır.
- Tasarım Prensibi 6 (TP6): FBÖA'nın teknolojiyle etkili SBK öğretimini geliştirme çalışmaları, teorik ve pratiği bir araya getirmelidir.
- Tasarım Prensibi 7 (TP7): FBÖA'nin akranlarıyla işbirliği yapmasına olanak sağlanmalıdır.
- Tasarım Prensibi 8 (TP8): FBÖA'na SBK'ın etkili öğretimi ile ilgili rol modelleri sağlanmalıdır.
- Tasarım Prensibi 9 (TP9): FBÖA teknolojiyle SBK öğretimi tecrübelerinde desteklenmelidir.
- Tasarım Prensibi 10 (TP10): FBÖA, teknoloji-entegre edilmiş SBK öğretimi pratikleri hakkında kritik düşünmeye çalıştırılmalıdır.
- Tasarım Prensibi 11 (TP11): FBÖA'nın teknoloji entegre edilmiş SBK öğretim pratikleri hakkında üstbilişleri, üstbilişsel süreçlerin çalıştırılmasının kendi gelişimlerine etkisi açıkça belirtilerek aktive edilmelidir.
- Tasarım Prensibi 12 (TP12): FBÖA'nın teknoloji ile etkili SBK öğretim pratikleri onları tasarım sürecine dahil ederel geliştirilebilir.

3. Yöntem

McKenney ve Reeves'in (2012) belirttiği gibi "eğitim tasarım araştırmaları karmaşık ve çok-yönlü bir çabadır" (s.13). Diğer araştırmalarla benzer özelliklere sahip olmakla birlikte, literatürde bahsedilen ETA'na özgü bazı özellikler bulunmaktadır. ETA esnek, müdahaleci, işbirlikçi, fayda odaklı, süreç odaklı, pragmatik, bağlamsal, etkileşimli, iteratif, bütünleştirici, içeriğe dayalı, metodolojik olarak kapsayıcı, çok seviyeli, teorik ve dönüştürücü olarak nitelenmektedir (Cobb et al., 2003; McKenney& Reeves, 2012; Plomp, 2013; van den Akker, Gravemeijer, McKenney, & Nieveen, 2006). Bu çalışma, ETA'nın en sık belirtilen özelliklerini taşımaktadır:

- Pragmatik
- İşbirlikçi
- Teorik olarak yönlendirilmiş
- Müdahaleci
- İteratif

3.1. Katılımcılar

Katılımcılar, Ankara'daki kamu üniversitelerinden birinin öğretmen yetiştirme programında bir dönemlik lisans dersine kayıtlı 80 fen bilgisi öğretmen adayıdır. Ders, ilköğretim fen bilgisi eğitimi programında zorunlu ders olarak sunulmaktadır. Bu nedenle, katılımcılar bu dersi programın ders gerekliliklerini yerine getirmek için almışlardır. İlk uygulamada 36 (4 erkek, 32 kadın) FBÖA ve ikinci uygulamada 44 (6 erkek, 38 kız) FBÖA dersi almıştır. Bütün FBÖA'ndan çalışmaya gönüllü olarak katılmaları istenmiştir.

3.2. Veri Toplama Araçları

Çalışmanın amacına ulaşmada dersin etkinliğini değerlendirmek için çeşitli veri toplama araçları kullanılarak süreç ve sonuç değerlendirmeleri yapılmıştır. Bu veri toplama araçları ve amaçları, Tablo 1'de özetlenmiştir.

Tablo 1

Veri Toplama Yöntemleri

Veri toplama aracları	Araçların amaçları	Veri toplama zamanı ve süresi
Grup ders planları (GDP)	Teknoloji destekli SBK öğretimi ile ilgili olarak FBÖA'nın bilgilerini gruplar halinde araştırmak	Her iki uygulamada da dönem boyunca
Bireysel ders planları (BDP)	Teknoloji destekli SBK öğretiminde FBÖA'nın bilgisindeki gelişmeyi araştırmak	Her iki uygulamada da final projesi olarak dönem sonunda
Video kayıtları	Video uyarılmış geri çağırma görüşmeleri, video yorumları ve yansıtıcı düşünce raporu 2'nda kullanılmak üzere FBÖA'nın SBK öğretim deneyimlerini kaydetmek için Teknolojiyle SBK öğretimi performanslarınn etkililiğini değerlendirmek için	Birinci uygulamada, her grup için yaklaşık bir saat İkinci uygulamada; her grup için yaklaşık bir buçuk saat (öğretim için başlatma faaliyetleri için yarım saat ve takip eden haftada öğretim performansları için bir saat)
Yansıtıcı düşünce raporu-1 (YDR_1)	FBÖA'nın SBK öğretimleriyle ilgili üstbilişlerini araştırmak için	İlk uygulamanın başlangıcında İkinci uygulamanın başlangıcında değiştirilmiş bir versiyonu
Yansıtıcı düşünce raporu-2 (YDR_2)	FBÖA'nın SBK öğretimleri süreciyle ilgili üstbilişlerini araştırmak için (Eğitim performanslarının video kayıtlarını izledikten sonra, FBÖA verilen soruları cevaplayarak kendi performanslarını izlemiş ve değerlendirmiştir)	İlk uygulamada, gruplar, öğretim performansını takip eden hafta raporlarını teslim etmişlerdir İkinci uygulamada, FBÖA gruplarının ikinci öğretim performanslarını takip eden haftada basitleştirilmiş bir versiyonunu teslim etmişlerdir.
Yansıtıcı düşünce raporu-3 (YDR_3)	FBÖA'nın post-aktif aşamadaki üst bilişini araştırmak Yeniden tasarlanan dersin etkinliği ile ilgili FBÖA'nın düşüncelerini araştırmak	Birinci uygulamada, her FBÖA, final tarihine kadar göndermiştir.
Öğretim sonrası yapılandırılmış görüşmeler (OSYG)	FBÖA'nın SBK öğretimleriyle ilgili üstbilişlerini araştırmak için	İkinci uygulamada, 20 gönüllü katılımcıyla, ikinci öğretim performanslarından sonra ve VUGG öncesi görüşülmüştür
Video-uyarılmış geri çağırma görüşmeleri (VUGG)	FBÖA'nın eğitim uygulamalarının altında yatan interaktif üstbilişini araştırmak	Birinci uygulamada, dönem sonuna doğru İkinci uygulamada, gruplarının ikinci öğretim performanslarından en fazla 48 saat sonra

3.3. Veri Analizi

FBÖA'nın SBK öğretim uygulamalarının niteliğini anlamak için ders planları, mülakatlar ve yansıtma kağıtlarında içerik analizleri yapılmıştır. Nitel verilerin içerik analizinden sonra, SBK Öğretimine Teknoloji Entegrasyonu için Bir Ders Planı Değerlendirme Rubriği (SÖTE-DPDR) ve SBK Öğretimine Teknoloji Entegrasyonu için Öğretim Performansı Değerlendirme Rubriği (SÖTE-ÖPDR) oluşturulmuştur.

Her iki rubric için de ortak olmak üzere rubriklerde 10 kriter bulunmaktadır. Her kriter için 4 seviye belirlenmiştir. Rubrikler SBK öğretimi alanında uzman olan 3 ve teknolohi entegrasyonu alanında uzman olan 3 araştırmacı ile geliştirilmiştir. TPAB alanında uzman bir araştırmacı ve SBK öğretimi alanında uzman olan bir araştırmacı verilerin %10'unu rubrikleri kullanarak analiz etmiştir. Daha sonra değerlendiriciler arası güvenirlik değerleri hesaplanmıştır. Bu amaçla sınıf içi korrelasyon katsayısı ve alfa güvenirlik katsayısı hesaplanmıştır.

SÖPE-DPDR için rtalama sınıf içi korrelasyon katsayısı .842 ($F(99,198) = 6.727$, $p<.001$) olarak bulunmuştur. Bu değer rubriğin iyi güvenirliğe sahip olduğunu göstermektedir. Aynı şekilde alfa güvenirlik katsayısı .851 olarak hesaplanmıştır. SÖPE ÖPDR'nin güvenirliğinin de .806 sınıf içi korrelaston katsayısı ve .801 alfa değeri ile iyi derecede olduğu bulunmuştur.

3.4. Tasarım Süreçleri

Analiz ve keşif aşamasındaki ürünler tasarım ve yapım aşamalarını yönlendirdiler. . İkinci aşamada literatüre dayalı olarak oluşturulan tasarım prensipleri ışığında, dersin prototipleri, çalışmanın ilk aşamasında belirlenen teorik çerçeve ile uyumlu olarak tasarlandı. ETA'nın bu fazında dört aşama vardı (Aşama 3 - Aşama 6). İkinci fazing aşamaları ve her aşamanın Tablo 2'de özetlenmiştir.

Table 2

Tasarım ve Yapım Aşamasındaki Aşamaların Çıktıları

Ikinci fazing aşamaları	Aşamaların çıktıları
Aşama 3: İlk prototipin geliştirilmesi	Dersin ilk prototipi ve dersin her bölümü için ilgili tasarım prensipleri - Anlama Bölümü: TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP11 - Gözlem Bölümü: TP8 - Pratik Bölümü: TP6, TP7, TP9, TP12 - Yansıtıcı Düşünme Bölümü: TP10
Aşama 4: İkinci prototipin geliştirilmesi	Dersin ikinci prototipi ve dersin her bölümü için ilgili tasarım prensipleri - Anlama Bölümü: TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP11 - Gözlem Bölümü: TP8 - Pratik Bölümü: TP6, TP7, TP9, TP12 - Yansıtıcı Düşünme Bölümü: TP10 - Düzeltme Bölümü: TP13 Eklenen tasarım prensibi - TP13: FBÖA teknolojiyle etkili SBÖ öğretimi ile ilgili bilgilerini gözden geçirme ve uyarlama fırsatı verilmelidir.
Aşama 5: Üçüncü prototipin geliştirilmesi	Dersin üçüncü prototipi ve dersin her bölümü için ilgili tasarım prensipleri - Anlama Bölümü: TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP11 - Gözlem Bölümü: TP8, TP14 - Pratik Bölümü: TP6, TP7, TP9, TP12 - Yansıtıcı Düşünme Bölümü: TP10 - Düzeltme Bölümü: TP13 Değiştirilmiş tasarım prensipleri - TP8: FBÖA'na teknolojiyle SBK öğretimiyle ilgili onlarla bezerlik gösteren rol modelleri sağlanmalıdır. Eklenen tasarım prensibi - TP14: Öğretmen eğitmenleri, SBK öğretim uygulamalarına kendi teknoloji entegrasyonları hakkında açık modelleme sağlamalıdır.
Cycle 6: Son prototipin uygulanması	Ikinci uygulamadan elde edilen veriler.

Uygulamalarda toplanan verilerin sonuçlarını ve aşamalarla ilgil ikritik düşünmeleri dikkate alarak, dersin son prototipinin beş bölümü içermesi kararlaştırılmıştır. Dersin ilk bölümünde, SBK öğretimi, TPAB ve öğretmen üstbilişiyle ilgili teori ve kavramların tanıtılması amaçlanmıştır.

TPAB-Gözlem olarak adlandırılan ikinci aşamada FBÖA'na teknoloji ile SBI öğretiminin iyi uygulamaları verildi. Bir sonraki aşamada, TPACK-Pratik, FBÖA'nın teknoloji ile SBK dersleri planlama ve öğretme eğitimi pratikleri kazanmaları bekleniyordu.

TPAB- Yansıtıcı Düşünme aşamasında, FBÖA'nın kendi ve diğer grupların SBK öğretim performansları hakkında düşünmesi bekleniyordu. Son aşamada (TPAB-Düzeltme), FBÖA'nın etkili SBK öğretimi hakkındaki düşüncelerini gözden geçirmesi ve dersin sonunda planlanan bireysel ders planlarına yansıtması bekleniyordu.

3.5. Verilerin Güvenirliği

Detaylı açıklama: Yeniden tasarlanmış lisans dersinin tasarlama ve uygulama süreçlerini, okuyucuların ve araştırmacıların teorik ve pratik bilgileri kolayca anlayabilmeleri için mümkün olduğunca kapsamlı ve ayrıntılı olarak tasarlama ve uygulama sürecini rapor ettim.

Üçleme: Her veri toplama yönteminin sınırlamalarını aşmak için veri toplama yöntemlerilmiş ve ders planları, video kayıtları, röportajlar ve öğrenci eserleri gibi farklı very kaynakları kullanılmıştır. Dahası, veri analizinde, farklı araştırmacılar veriyi kodlamıştır. Üst biliş ve TPAB alanında deneyimli araştırmacılar, verilerin bir bölümünü kodladı.

Uzun süreli katılım ve sürekli gözlem: Araştırmacı olmanın yanı sıra, aynı zamanda yeniden tasarlanan dersin asistanıydım. Bu nedenle, katılımcılar ile ilişki geliştirdim ve güven inşa ettim.

4. Bulgular: Fen Bilgisi Öğretmen Adaylarının Teknolojiyle SBK Öğretim Pratiklerinin Gelişimi

FBÖA'nın teknolojiyle SSI öğretim uygulamalarının etkinliğini etkileyen farklı konular vardır. (a) durum bazlı konular, (b) sınıf söylemi konuları, (c) bilimin doğası konularo ve (d) kültürel meseleler. Bu bölümde, bu konular ayrı ayrı açıklanmıştır.

4.1. Durum-Bazlı Konular

SBK eğitiminin etkililiğini etkileyen bazı durum bazlı sorunlar vardır. Öncelikle, seçilen SBK durumu bazı özelliklere sahip olmalıdır. Öğrenciler, seçilen SBK hakkında gerçek yaşam deneyimine sahip olmalıdır. Seçilmiş SBK konularının bilimsel temellerinin karmaşıklığı öğrencilerin anlaması için uygun olmalıdır. Üstelik, seçilen SBK durumu, kaygı ve empati geliştirmede kullanışlı olmalıdır. Ardından, seçilen SBK durumu mümkün olduğunca spesifik olmalıdır ki böylece öğrencilerin iddialarını oluşturma ve kanıt bulma işlemlerini gerçekleştirebilmesine olanak sağlamalıdır.

FBÖA'nın kullandığı SBK durumlarının seçim kriterlerine ek olarak, SBK durumu hakkındaki bilgileri de SBK öğretiminin etkinliğinde etkili olabilir. Öğretmen, seçilen SSI konusuyla ilgili tüm görüşleri farklı bakış açılarından öğrenmelidir. Böylece FBÖA'ları sınıf söylemini kolayca yönetebilir, SBK'nun çok perspektifli niteliğini gösterebilir ve öğrencilerin öğrenmesi hakkında nelerin değerlendirileceğine karar verebilir.

Planlama sürecine başlamadan önce, tüm FBÖA, SBK öğretim bakış açısıyla fen müfredatını incelemek üzere yönlendirildi. Ardından, müfredatta belirli bir konuyu ilgili sosyobilimsel bir durumla ele almaya karar verdiler.

FBÖA'nın bazıları, grup ders planları için SBK durumu seçimlerini yansıtıcı düşünce raporlarında ve görüşmelerinde belirttiler. Bazı gruplar, öğrencilerin kendi hayatları için konunun önemini kavramasını kolaylaştıracak SBK durumu seçmeye çalıştı. Bu nedenle, hedef öğrencileri için öğrenilmesi gerekli ve anlamlı SBK durumlarını seçmeye çalıştılar.

İlgili ve anlamlı SBK durumlarını seçebilmek için, gruplar farklı ölçütlere odaklanmıştır. FBÖA SBK durumlarını öğrenciler SBK konusuyla ilgili deneyime sahip oldukları için seçtiler. FBÖA'nın belirttiği bir diğer kriter de, durumun, SBK'nun anlaşılmasına olanak tanıyan karmaşık kavramlar ve süreçler içeren bilimsel arka plan içermediğidir. Bunların dışında, empati geliştirme olasılığı nedeniyle konuyu seçtiler.

Öğrencilerin gerçek yaşama deneyimine sahip oldukları bir SSI durumunu seçen gruplar, seçilen konunun öğrencilerin sınıf söylemine katılımı üzerindeki olumlu etkisini gözlemledi. Bu nedenle, daha fazla FBÖA, nükleer santral yapımı ve genetiği değiştirilmiş gıdalar gibi güncel konuları seçti. Ülkenin farklı yerlerinde farklı nükleer santral inşaatı planı yapıldığı için, günlük diyetlerinde genetiği değiştirilmiş gıdalara maruz kaldıklarından, öğrencilerin bu konular hakkında gerçek yaşam deneyimlerine sahip olma ihtimalleri yüksekti.

FBÖA'nın SBK durumunun bilimsel temelleri hakkındaki düşüncelerini özetlemek gerekirse, FBÖA müfredatı önceki konunun hedeflerini temel alarak belirlemek için müfredatı analiz etmiş olmasına rağmen, öğrencilerin SBK bilgilerini anlamalarına katkıda bulunabilecek veya engel edebilecek gerçek bilgiyi belirlemekte genellikle güçlük çektiler. Benzer şekilde, FBÖA öğrencilerin SBK'ı anlamalarını engelleyebilecek olası kavram yanılgılarını ortaya çıkarmada ve üstesinden gelmekte zorlandı. Öğrencilerin ön bilgilerini etkin bir şekilde belirleyen ve etkinleştiren gruplar, SBK'nun bilimsel temellerinin karmaşıklığını belirlemede de etkililerdi.

FBÖA SBK seçimlerinde kaygı ve empati geliştirmeyi çok fazla göz önünde bulundurmadılar. Ancak SBK durumlarını öğrencilerin günlük yaşama çok yakın seçen gruplar, öğretiminde kaygı ve empati geliştirmenin önemini gözlemledi. Örneğin, , ikinci uygulamanın ilk grubu öğretim performanslarında hidro elektrik santral (HES) yapılmasını ele aldı. Öğrencilerin bir kısmı HES bölgelerindendi. Bu nedenle, orada yaşayan insanların deneyimlerini biliyorlardı. Bu nedenle, orada yaşayan düşük sosyo ekonomik statüye sahip insanlara karşı empati geliştirdikleri için, ekonomik perspektiften argümanlar hazırladılar. Orada yaşayanlar için iş olanakları sağlama konusundaki HES rolüne odaklandılar. FBÖA'nın açıklamasına göre, bu grup, yerlilerin ekonomik sorunları için çözümler bulmaya çalıştıklarından, tartışmaya katılan en etkili grup oldu.

FBÖA, öğrencilerin katılımı konusunda kaygı ve empati geliştirme ihtimaline sahip SBK durumlarının rolünü tecrübe ettiklerinden, kendi ders planlarında SBK durumlarını seçerken buna dikkat ettiler. Bu sebeple organ ve doku bağışı, hayvanların deneylerde test edilmesi, kök hücre, antibiyotik ve diyet hapı kullanımı gibi konuları seçmişlerdir. Bu konularda hastaların sorunlarına çözüm bulmayı içerdiği için öğrenciler hastalara karşı kolayca kaygı ve empati geliştirebilirler.

FBÖA ayrıca, SBK durumunun mümkün olduğunca spesifik olması gerektiğini düşünüyorlardı; böylece öğrencilerin iddialarını oluşturması ve karşı argümanları çürütmek için kanıt bulmaları mümkün oluyordu. İkinci uygulamanın yedinci grubu bunu başardıklarını düşünüyordu. Böylece, öğrenciler aktif olarak tartışmaya katıldılar.

Öte yandan, ilk uygulamadaki birinci ve sekizinci grup, kendi gruplarının SBK öğretim performanslarını SBK durumunlarını spesifik hale getirememe konusunda eleştirdiler. Seçtikleri konu çok genel olduğu için öğrencilerin diğer grupların iddialarına karşı argüman üretemediğini düşünüyorlardı, çünkü çok sayıda tartışılacak argüman vardı.

İlk uygulamanın sekizinci grubunun grup üyeleri, bu sebeple öğrencileri karşı argümanları çürütmek için kanıt bulmaya yönlendirmede zorlandı. Öğrencilerin tartışma kalitesini sağlamak için öğrencileri bu konuda her zaman uyarmak zorunda hissettiklerini belirttiler. Bu nedenle, böyle geniş bir konudaki sınıf söylemiyle uğraşma konusundaki deneyimlerine dayanarak, konunun mümkün olduğunca daraltılması gereğini belirttiler.

Özetle FBÖA, seçilen SBK durumunun konusunun öğretim performansının etkinliğindeki rolünü belirtti. Teorik bilgi ve öğretme performansındaki deneyimlerine dayanarak, durum bazlı konuların SBK öğretimine etkisi hakkında fikir sahibi oldular. Her ne kadar öğrencilerin ön bilgi ya da konuyla ilgili kavram yanılgılarını belirleyebiliyor ve bunları göz önüne alarak iyi bir ders planı hazırlayabiliyor olsalar da, seçilen konu uygun olmadığı takdirde, öğretimde etkili olmayabildiklerini farkettiler. Bu nedenle SSI öğretiminde konu seçiminin önemini takdir ettiler. Öğrencilerin öğrenmesi için anlamlı ve anlamlı olan bir SBK durumu seçtikleri takdirde, öğrencilerin aktif katılımını sağlayıp ve tartışmacı söylemi kolaylıkla yönetebileceklerini gördüler.

Seçilen SBK durumunun özelliklerine ek olarak, FBÖA'nın seçilen SBK hakkındaki bilgileri de SBK eğitiminde etkinliklerinde etkili olmuştur. SBK eğitimindeki etkin gruplar, başarılarını konuyla ilgili argümanlar açısından iyi hazırlanmış olmalarına bağladılar. Bütün grup üyelerinin iddiaları incelediğini ve hepsinin etkili bir biçimde öğrencilere rehberlik edecek kadar bilgili olduğunu belirttiler.

4.2. Sınıf Söylemi Konuları

Dersin 'anlama' bölümünde SBK öğretiminin pedagojisi tartışıldı. Bu nedenle, FBÖA'nın SBK pedagojisine ilişkin makaleleri okumaları bekleniyordu. Zeidler ve ark. (2004) tarafından tanımlanan SBK eğitimi için araştırmaya dayalı çerçeve SBK'nın etkililiğini etkileyen konular üzerinde durularak tartışıldı. Dolayısıyla argümantasyonun pedagojik gücü ve öğrencilerin bilimle ilgili görüşlerini tartışma yoluyla geliştirmenin önemi vurgulanmıştır. Dolayısıyla, bu bölümde, grupların hem yazılı hem de sözlü olarak argümantatif söylem düzenlemedeki pedagojik kararları açıklanmıştır.

Öğrencilerini argümantatif söyleme dahil edebilmek için FBÖA grup ve bireysel ders planlarında farklı öğretim yöntemleri kullanmayı planladı. İşbirlikli öğrenmenin en sık kullanılan öğretim stratejisi olduğu bulundu. Sorgulama, tartışma ve doğrudan öğretim sıklıkla seçilen diğer öğretim stratejileri olarak bulunmuştur.

FBÖA grup ve bireysel ders planları için seçtikleri öğretim stratejisinin avantaj ve dezavantajlarından söz ettiler. Ayrıca, öğretim stratejisinin dezavantajlarının üstesinden gelmek ve argümantasyonun uygulanmasını kolaylaştırmak için teknolojiden yararlanacaklarını belirttiler. Bu nedenle, FBÖA teknolojiyi öğretim stratejisinin kullanımını zenginleştirecek bir şekilde kullanmayı planlamışlardır.

Teknolojiyi kullanma gerekçeleri genel olarak şu şekilde categorize edilmiştir: bilgi vermek, iletişimi sağlamak, araştırma ortamı sunmak, sınıfı yönetmek, görselleştirmek, motive etmek ve değerlendirme yapmak. FBÖA'nın teknoloji entegrasyonu stratejileri öğrenci merkezli ve öğrencilerin kendi bilgilerini oluşturmasına izin verme fikrine dayanmaktaydı. Teknolojileri öğretimlerini sosyal yapılandırmacı öğrenmeye dayanan araştırma temelli, öğrenci merkezli bir yaklaşıma dönüştürmek için kullandılar.

FBÖA'nın grup ve bireysel ders planlarındaki teknoloji entegrasyon stratejileri arasında farklılıklar vardı. Her ne kadar araştırma, görselleştirme, bilgi verme, motive etme, iletişim, sınıf yönetimi ve değerlendirme grup ders planlarında en sık seçilenlerden en az seçilenlere nedenler olsa da, her bir kategori için frekansların sırası bireysel ders planlarında farklılıklar gösterdi. FBÖA bireysel ders planlarında en çok bilgi vermek ve iletişimi sağlamak için teknolojiyi kullanmaya karar verdiler.

Bu farklılıklar, FBÖA'nın teknoloji kullanımının en önemli sebebinin argümantasyonu kolaylaştırdığını gösteriyor. Bilgiyi vererek ve iletişim sağlayarak FBÖA argümantasyonun uygulanmasını kolaylaştırmayı hedeflemişlerdir. Öte yandan, grup ders planlarında iletişimi sağlama en az belirtilen nedenler arasındaydı. Bu durum FBÖA'nın öğretim stratejilerine teknolojiyi entegre ederek teknoloji ile SBK öğretiminin etkililiğini nasıl artıracaklarını öğrendikleri şeklinde yorumlanabilir.

Argümantasyonla ilgili pratik bilgi açısından ikinci uygulamadaki gruplar ilk uygulamadaki gruplardan daha iyiyidi. Argümantasyonu etkili bir şekilde yöneterek tartışmaları akıcı hale getirmişlerdir. Öğrencilerinden sürekli olarak kanıt sunmalarını, argümanlarını farklı perspektiften değerlendirmelerini ve karşıt görüşleri uygun delillerle çürütmeye çalışmalarını isteyerek onların argümantasyon becerilerini arttırmaya çalışmışlardır. Bunu yaparken öğrencilerin fikirlerini takip etmede etkili olmuşlardır.

Genellikle, argümantasyonun uygulanmasının kalitesi birinci gruptan son gruba doğru artmıştır. Her iki uygulamada da son gruplar argümantasyonu en etkili uygulayan gruplar olmuştur. Ayrıca, teknolojiyi argümantasyon sürecine etkin bir şekilde dahil etme becerileri de son gruplara doğru artmıştır. Teknoloji entegrasyonu konusunda ikinci uygulamadaki gruplar daha etkili olmuştur. Ikinci uygulamadaki gruplar teknolojiyi daha yaratıcı ve işlevsel bir şekilde kullandı.

4.3. Bilimin Doğası Konuları

SBK bağlamında düşünme ve bilimin doğası anlayışı arasında iki yönlü bir ilişki vardır. Birincisi, SBK bağlamında bilim öğretmek öğrencilerin NOS anlayışının geliştirilmesine katkıda bulunur. Öte yandan, SBK bağlamında düşünmek, öğrencilerin bilimin doğasıyla ilgili görüşlerinden önemli ölçüde etkilenmektedir. Bu nedenle, öğretmenler hem öğrencilerinin bilimin doğası anlayışını geliştirmeyi hem de bilimin doğası hakkındaki epistemolojik yönelimlerini bilerek SBK öğretimlerini planlamayı amaçlamalıdır.

FBÖA'nın bilimin doğasıyla ilgili anlayış geliştirmeyi hedefleyip hedeflemediklerini anlayabilmek için ders planlarındaki kazanımlar incelenmiştir. FBÖA'nın ders planlarına fen müfredatının dört öğrenme alanından kazanımlar yazmaları bekleniyordu. Bilimin doğası ile ilgili kazanımlarını bilgi, beceri ve Fen Teknoloji Toplum Çevre (FTTÇ) öğrenme alanına dahil ettiler. NOS'un öznelliği ile ilgili hedefler ağırlıklı olarak yazıyorlardı. Sayısı az olmakla beraber, FBÖA bilimin öznel, yaratıcı, ampirik temelli ve sosyo-kültürel doğası ile ilgili hedefler yazmışlardır.

FBÖA'nın bilimin doğasıyla ilgili yazdığı bazı kazanımlari, onların bilimin doğasıyla ilgili yanlış anlamalarını ortaya çıkarmıştır. Bilimin doğasıyla ilgili yanlış anlamalar içeren kazanımların sayısı ikinci uygulamada daha azdır. Ikinci uygulamada bilimin doğası kazanımlarında yanlış anlaşılma tespit edilen grup yokken, ilk uygulamada üç grup bulunmaktadır. Benzer şekilde, yanlış anlaşılma tespit edilen bilimin doğası kazanımlarını yazan FBÖA sayısı, ilk uygulamadaki FBÖA sayısı (n_{FI} = 14) ile karşılaştırıldığında ikinci uygulamada (n_{SI} = 2) daha düşüktür.

Özetle, FBÖA öğrencilerin bilimin doğası anlayışını geliştirebilecek kazanımlar yazmakta iyi değillerdi. Bununla birlikte, öğrencilerin bilimin özellikle sosyokültürel ve öznel doğasını anlamalarına yardımcı olmak için etkinlikler düzenleyebildiler. Grupların

SBK öğretirken derste yaptırdıkları aktiviteler öğrencilerin bilimin doğasını örtük bir şekilde anlamasını sağlamasına ragmen, çok az grup (n_{FI}=2, n_{SI}=2) açık bir şekilde derste bilimin doğası vurgusu yapmıştır.

FBÖA'nın öğrencilerinin epistemolojik inançlarıyla ilgili görüşleri derslerini planlamasına etki etmiştir. İkinci uygulamadaki FBÖA'nın çoğu, öğrencilerin internet araştırmaları sonucunda ulaştıkları kaynakları yanlı bilgi içerip içermediğine göre elemekte zorluk çekeceklerini düşünmüşlerdir. Bu nedenle, güvenilir kaynakların sağlanmasının gerekli olacağını düşünmüşlerdir. FBÖA, SBK öğretim pratiklerinde yaptıkları öğrencilerin epistemolojik inançlarıyla ilgili gözlemlerine dayanarak bireysel ders planlarında öğrencilere güvenilir kaynakların hazır olarak verilmesinin gerekli olduğuna karar vermişlerdir. Ayrıca, öğrencilerini internetten ulaşabilecekleri yanlı kaynaklar konusunda konusunda uyarmaya karar verdiler.

Bazı FBÖA öğrencilerin bilimin doğası ya da eistemolojik inançları dışındaki inançlarının da SBKda öğrenmelerini etkilediğini belirtmişlerdir. Bazı FBÖA, bazı öğrencilerin iddialarına derinden bağlı olduklarını bu nedenle, diğer grupları ikna etmek için kanıtlarını çarpıtma eğilimi gösterdiklerini gözlemlemişlerdir. Ayrıca, öğrencilerin argümanlarına olan bağlılığının sınıf olarak karar verme sürecini de etkilediğini gözlemlemişlerdir. Öğrencilerin iddialarından vazgeçmek istemediğinden, karar vermede diğer grupların iddialarını dikkate almayıp ortak karara varmakta zorlandıklarını belirtmişlerdir.

Daha önceki grupların öğretimleri sırasında öğrencilerin sınıf kararına varmalarını sağlamada karşılaştıkları zorlukları göz önüne alarak, sonraki gruplar öğrencileri sınıf tartışmasına sokmaya teşvik eden daha etkili stratejiler bulmaya çalıştı. Bu nedenle, argümantasyonu uygulamalarını kolaylaştıracak şekilde paneller düzenlediler. Bu sayede öğretmenler, öğrencilerin diğer grupların kanıtlarını değerlendirmesini ve daha fazla delil sunmasını kolaylıkla sağlayabilmişlerdir.

4.4. Kültürel konular

Araştırmacılar, SBK öğretiminin öğrencilerin ahlaki ve etik uslamlamalarını geliştirmesi gerektiğini vurgulamışlardır. Bu nedenle, öğretmenlerin öğrencilerin ahlaki gelişim düzeyinin farkında olmaları ve öğrencilerin ahlaki gelişimlerine katkıda bulunmanın yollarını aramaları çok önemlidir. FBÖA'nın öğrencilerinin gelişim düzeyleri (bilişsel ve ahlaki) hakkındaki farkındalığı araştırılmıştır. Böylece, ahlaki uslamlamayı geliştirmeye yönelik etkin SBK seçme becerileri belirlendi. Üstelik, SBK öğretiminde ahlak kurallarını ele alış biçimleri incelendi.

Genel olarak, FBÖA grup ders planlarında öğrencilerin gelişim düzeylerini belirlemede iyi değildi. Öte yandan, kendilerinin ve diğer grupların SBK öğretimi performancları hakkında kritik düşünmeleri sayesinde FBÖA, öğrencilerin SBK hakkında etkili bir uslamlama yapabilmeleri için bilişsel ve ahlaki gelişim düzeyinin önemi konusunda daha fazla farkındalık kazanmıştır. Bu nedenle, bu farkındalıklarını bireysel ders planlarına yansıtmışlardır.

FBÖA'nın etik ve ahlak konularını nasıl ele aldıklarını anlamak için grup ders planları ve bireysel ders planları analiz edilmiştir. Etik konuları SBK öğretiminde farklı biçimlerde ele aldılar. Bazıları SBK konusundaki tartışmalara etik yönlerini de eklediler veya tartışmalarında etik konuları göz önünde bulundurmalarını gerektiren yönlendirici sorular sordular. Öte yandan, bazıları SBK'nun sadece etik yönünü ele aldı.

Gruplar (n_{FI}=1) ve FBÖA (n_{FI}=2, n_{SI}=10) çoğunlukla öğrencilerin SBK'yu farklı yönleden tartışmalarını istediler. Bu yönlerden birisi olarak etik yönünü de içerirler. Bu PST'ler öğrencilere bilim adamı, yasa koyucular, halk, doktorlar veya ekonomistler gibi roller verdiler. Bunların yanında bazı öğrencilerin de ahlakçı (ethicist) gibi davranmalarını istediler.

İkinci uygulamadaki FBÖA ekonomi, bilim veya mevzuat gibi diğer yönlerin yanı sıra planlarında SBK'nun etik yönünü de içermektedir. Öte yandan, ilk uygulamadaki FBÖA daha çok SBK'nun sadece etik yönünü ele almayı tercih ettiler. FBÖA'nın seçtiği etik kaygıları ele alan konular genellikle genetikle ilgili konulardı. Enerji veya çevreyle ilgili

SBK da ele almış olmalarına rağmen, bu konuların öğretiminde etiği dikkate almıyorlardı. Genellikle biyoetik üzerine odaklandılar.

5. Bulgular: FBÖA'nın Üstbilişsel Düşünce Yapıları ve Farklı Üstbilişsel Düşünce Yapısına Sahip FBÖA'nın Sosyobilimsel Konu Öğretimine Teknoloji Entegrasyonu

Bu bölümde, SBK'ın öğretimiyle ilgili üst bilişsel düşünce yapıları anlatılmıştır. Öncelikle üstbilişsel düşüncelerini etkileyen bilgi, inanç ve amaç faktörleri hakkındaki bulgular açıklanmıştır. Daha sonra FBÖA'nın SBK öğretimleri öncesindeki, öğretimleri sırasındaki ve öğretimleri sonrasındaki üstbilişsel düşünceleri bilgi, inanç ve amaçlarıyla ilişkilendirilerek ortaya konulmuştur. FBÖA'nın üstbilişsel düşünce yapıları her bir alt boyut için iki farklı kategoride gruplanmıştır. Daha sonra, SBK öğretimiyle ilgili farklı üstbilişsel düşünce yapılarına sahip FBÖA'nın SBK öğretimi için TPAB'leri dönem sonunda hazırladıkları ders planlarına göre karşılaştırılmıştır.

FBÖA'nın üstbilişsel düşünce yapıları biliş bilgisi ve bilişin düzenlenmesi öğeleri için ayrı ayrı anlatılmıştır. Alan bilgisi açısından FBÖA'nın iki farklı üstbilişsel düşünceye sahip olduğu tespit edilmiştir. Bir grup FBÖA (X Grubu) kendi alan bilgilerinden tamamen emin olsa da, diğer grup (Grup Y) kendi alan bilgilerine çok fazla güvenmemektedir. FBÖA'nın kendi alan bilgilerine ilişkin değerlendirmelerine göre X grubu kendi SBK'yla ilgili olası tüm argümanların farkındalığını ortaya koymuştur. Farklı perspektiflerden olası öğrenci argümanlarına hazırlamış hissettiklerini belirttiler. Öte yandan, Grup Y, beklenmedik öğrenci argümanlarına cevap vermek için kendilerini yetersiz hissetti.

Benzer şekilde, FBÖA pedagoji bilgileri hakkında iki farklı üstbilişsel düşünce yapısına sahipti. FBÖA'nın açıklamalarına göre, bir grup FBÖA (Grup X), seçilen öğretim stratejisi hakkında kendilerine tam bir güven duymuş ve öğretim stratejisini kolaylaştırmak için uygun teknikleri ve teknolojileri seçmişse de diğer grup FBÖA (Grup Y) kendilerini öğretim stratejisini planlamak ve uygulamakta yetersiz hissetmiştir.

Biliş bilgilerine ek olarak, FBÖA'nın öğretim performansları öncesindeki, sırasındaki ve sonrasındaki düşünceleri de incelenmiştir. FBÖA preaktif, interaktif ve postaktif öğretim aşamaları boyunca üst bilişsel düzenlemeleri bakımından iki kategoriye ayrılmıştır. Bu iki kategorideki FBÖA'nın üstbilişsel düşünceleri birbirinden üstün değildir, ancak belli açılardan birbirinden farklıdır.

FBÖA'nın, ders planlaması aşamasındaki düşünceleri farklılık gösteriyordu. Bazı FBÖA (Grup X) öğrencilerin SBK'da muhakemelerine ve bunu sağlamak için planlanan etkinliklere daha fazla odaklanmış olmalarına rağmen, diğerleri (Grup Y) etkinliklerinin SBK'yla ilgili muhakemeye katkısını düşünmemişlerdir. Grup X öğretim ve değerlendirme planlarında SBK'yla ilgili akıl yürütme süreçlerine odaklanmıştır. Öğrencilerin çoklu perspektiflerin ve bu perspektiflerin ilişkilerinin farkında olmalarına yardımcı olmak ve onları hem toplumsal hem de bilimsel sorgulamaya teşvik etmek için faaliyetler planlamışlardır. Bu amaçlara ulaşmak ve SBK'yla ilgili akıl yürütme süreçlerine entegre etmek için uygun teknolojiler seçmişlerdir. Grup Y SBK muhakeme süreçlerine açıkça odaklanmadan takip edilecek süreçlere odaklanmıştır. Ayrıca, SBK muhamesine katkıda bulunacak teknolojiler seçmemişlerdir.

Öğretimlerinin interaktif aşamasındaki izleme becerisiyle ilgili Grup X kendilerinden çok eminken, Grup Y öğrencilerin aktiviteleri tamamlayıp tamamlamadıklarını izlemekten öteye gidememişlerdir. Grup X öğrencilerin fikirlerini gözlemlemiş, dinlemiş ve takip etmiş; öğrencilerin anlayıp anlamadıklarını, argümanlarının kalitesini ve teknoloji kullanma becerilerine odaklanmışlardır. Grup Y ise öğrencilerin katılımı ve görevlerini tamamlama ya da teknolojik araçları kullanma becerisine odaklanmışlardır.

Öğretimi düzenleme becerisi açısından Grup X öğrenci gelişimiyle ilgili gözlemlerine dayanarak öğretim sırasında gerekli değişiklikleri (örneğin, küçük grup tartışmaları için fazladan zaman verilmesi) yapabilmişlerdir. Öte yandan, Grup Y SBK öğretimlerini ders planlardan sapma olmaksızın gerçekleştirmeye çalışmış veya kaçınılmaz değişiklikler sırasında yaptıkları değişikliklerden çok emin olmamışlardır.

FBÖA'nın öğretim sonrası süreçteki değerlendirme becerileri de farklılık göstermiştir. Performanslarının derecelendirmesindeki odakları farklılık gösterdi. FBÖA'nın bazıları, öğrencilerinin kendi anlamlarını oluşturmalarına, SBK'da akıl yürütme becerilerinin geliştirilmesine ve bilimsel ve teknolojik okur yazarlığın geliştirilmesine yardımcı olma amaçlarına ulaşıp ulaşmadığına karar vermek için öğretimlerini değerlendirdiler. Öte yandan, diğer FBÖA kendi performanslarını değerlendiremedi. Genel olarak hedeflerine ulaşmada etkinliklerinin muhtemel etkinliği hakkında konuştular. Bununla birlikte, amacına ulaşıp ulaşmadıklarını değerlendirmediler. Dahası, sadece öğretme performanslarını, zaman ve sınıf yönetimi bakımından etkili olup olmadıklarına göre değerlendirdiler.

Son olarak FBÖA öğretimlerinin revizyonu için farklı öneriler sundu. Bir grup FBÖA (Grup X), deneyimlerine dayanarak SBK eğitiminin etkililiğini artırmak için düzeltme önerileri sundu. Ancak diğer FBÖA (Grup Y) düzeltmelerinde yalnızca daha iyi zaman yönetimi stratejilerine odaklandı.

Üstbiliş düşünceleri her bir bileşen için X grubunda kategorize edilmiş FBÖA'nın etkili SBK öğretimi için TPAB incelendiğinde, teknolojiyle SBK öğretimi ile ilgili öğretim stratejileri ve temsilleri hakkındaki bilgileri açısından grup ders planları ve bireysel ders planlarında aldıkları puanlar farklıdır. Bireysel ders planlarının KoIS puanları grup ders planlarından daha yüksektir.

PST'lerin, etkili SBK öğretmeki için müfredat ve müfredat materyalleri hakkındaki bilgisi (KoC) üst bilişsel düşüncelerine göre benzer bir model gösterdi. Üstbiliş düşünceleri her bir bileşen için Grup X olarak sınıflandırılan FBÖA'nın KoC puanı, bireysel ders planlarında grup ders planı puanlarına kıyasla daha yüksekti. Öte yandan, üst bilişsel düşünceleri her bileşen için Grup Y olarak kategorize edilen FBÖA'nın KoC puanları, bireysel ders planlarında gruplarının ders planı puanlarına göre daha düşüktü. X grubundaki FBÖA müfredat hedeflerine ulaşmak için teknoloji entegre etmeye odaklandı. Dahası, bu FBÖA'nın hedefleri öğrencilerinin SBK akıl yürütme becerilerini, bilimsel ve teknolojik okur yazarlığını geliştirmekti. Bu hedef doğrultusunda müfredatı etkin bir şekilde incelediler ve uygun müfredat hedeflerini seçip bu hedeflere ulaşmaya çalıştılar. Bu nedenle, müfredat bilgileri bireysel ders planlarında daha yüksekti.

Bununla birlikte, Grup Y'deki FBÖA, öğretim kalitesini artırmak için açık bir gerekçe olmaksızın SBK öğretimine teknoloji entegre etmeyi amaçladı. Öğretimlerini izlerken ve değerlendirirken, bu FBÖA çoğunlukla planlanan görevlerin zamanında tamamlanmasına odaklanmış ve öğrencilerin hedefe ulaşıp ulaşmadıklarını değerlendirmekten ziyade katılımlarını izlemişlerdir. Bu nedenle, bireysel ders planlarında SBK öğretimi için ilgili hedeflerin belirlenmesinde zorluk çekmişlerdir.

Üst bilişsel düşünceleri her bileşen için X grubu olarak kategorize edilen FBÖA'nın tamamı, kendi grup ders planlarına kıyasla bireysel ders planlarında öğrencişerin anlaması bilgisi (KSU) bakımından yüksek puana sahipti. Öte yandan, üst bilişsel düşünceleri her bir bileşen için Grup Y olarak kategorize edilenlerin KSU puanı, bireysel ders planlarında gruplarının ders planı puanlarına kıyasla daha düşüktü. Bu gruptaki FBÖA, öğretimlerinin öğrencilerin gelişimine olan etkilerini izleyebildiler. Bu nedenle, öğrencilerin SBK'da akıl yürütmelerine etki edebilecek ön bilgi ya da kavram yanılgıları konusunda emindiler. Dahası, öğrencilerin etik ve ahlaki uslamlamalarını etkili bir şekilde ele almışlardır. Bu nedenle, eleştirel olarak öğrencilerin akıl yürütmelerinde etkili olabilecek gelişim düzeylerini analiz ettiler. Yukarıdakilerden farklı olarak iki gruptada değerlendirme bilgisi bireysel ders planlarında düşmüştür.

FBÖA'nın üstbilişsel revise etme açısından düşünceleri bireysel ders puanlarının kalitesinde belirleyici olmuştur. FBÖA'nın üstbilişsel düşünceleridiğer üstbiliş öğeleri açısından Y grubunda değerlendirilse de eğer onların revize etme düşünceleri X grubuna ise bireysel ders planlarının puanı grup der planlarından daha yüksek olmuştur.

Üstbilişsel düşüncelerdeki farklılıkların bireysel gelişimle ilişkisi dışında, grup elemanlarının üstbilişsel düşünce yapılarının grubun performansıyla ilişkisi de ortaya konulmuştur. FBÖA'nın interaktif süreçteki üstbilişsel düşünce yapılarının öğretim performansının etkililiğinde belirleyici olduğu tespit edilmiştir. Eğer grup elemanlarının interaktif aşamadaki üstbilişsel yapıları grup X olarak categorize edilmişse grubun öğretim performansı puanı ders planı puanından daha fazla olmuştur.

6. Tartışma ve Öneriler

Bu eğitim tasarımı araştırması kapsamında, FBÖA'nın teknolojiyle etkili SBK öğretim uygulamalarını geliştirmek için bir lisans dersi tekrar tasarlanmıştır. Bu amaçla tasarlanacak dersin özelliklerini tanımlamak için ilk tasarım prensipleri literatürden alınmıştır. Çalışmanın aşamaları boyunca, bu ilkeler, yeniden tasarlanan dersin prototiplerinin uygulamalarından ve tekrarlayan literatür inceleme süreçlerinden elde edilen verilere dayanılarak revize edilmiş ve nihai tasarım prensipleri belirlenmiştir. Aşağıda, FBÖA'nın teknoloji ile olan SSI öğretme uygulamaları ve üstbilişleri hakkındaki temel bulgular tasarım ilkelerine göre açıklanmıştır.

Çalışmanın sonuçlarına göre yeniden dizayn edilen ders FBÖA'nın SBK öğretimlerinin durum bazlı konular ve sınıf söylem konularında gelişmeleri açısından oldukça etkili olmuştur. Ancak bilimin doğası ve kültürel konularda gelişimlerini sağlamak için bazı revizyonların yapılmasına ihtiyaç vardır.

Ayrıca FBÖA'larının öğretimleri hakkında üstbilişlerinin aktif hale getirilmesi onların SBK öğretimlerinin etkililiğini etkileyen faktörler açısındna farkındalıklarının artmasını sağlamıştır. Böylece SBK öğretimlerini daha etkin hale getirebilmek için gerekli strateji ve teknolojileri ekleyerek etkili ders planları hazırlayabilmişlerdir.

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