INVESTIGATING SCIENCE TEACHERS' CLASSROOM DISCOURSE AND STUDENTS' REASONING QUALITY THROUGH ARGUMENT-BASED INQUIRY APPROACH

GÜLŞAH ÖZKAN İNAL

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Prof. Dr. Yaşar Kondakçı
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Assoc. Prof. Dr. Elvan Şahin
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 Master of Science.

Prof. Dr. Özgül Yılmaz-Tüzün
Supervisor

Examining Committee Members

Prof. Dr. Jale Çakıroğlu (METU, ESME) __________________

Prof. Dr. Özgül Yılmaz-Tüzün (METU, ESME) __________________

Assist. Prof. Dr. Yılmaz Soysal (İstanbul Aydın Uni., TEB) __________________

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 : Gülşah Özkan Inal

Signature :

ABSTRACT

INVESTIGATING SCIENCE TEACHERS' CLASSROOM DISCOURSE AND STUDENTS' REASONING QUALITY THROUGH ARGUMENT-BASED INQUIRY APPROACH

Gülşah, Özkan İnal
M.S., Department of Elementary Science and Mathematics Education
Supervisor: Prof. Dr. Özgül Yılmaz-Tüzün

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This study had three purposes, first the science teachers' discursive moves (TDMs) during classroom discourse in medium and high levels of Argument Based Inquiry (ABI) implementation were investigated. Moreover, the relationship between the TDMs and their students' reasoning qualities was also explored in different levels. Finally, this study investigated types of communicative approach performed by teachers. The participants of this study were two elementary science teachers who were selected purposefully among teachers who attended the professional development (PD) program. These teachers' students were also involved in this study. The data source of this study was video recordings of ABI implementations. The data were analyzed with the systematic observation. The results of the current study revealed that both teachers conducted reflective discourse more and provided knowledge and evaluated students' response less in high levels of ABI implementation. However, they had difficulty in performing some discursive moves (challenging and seeking for evidence) in both levels. The changes in the percentages of TDMs (knowledge providing and evaluating, reflective discourse) were related to increasing students' reasoning qualities because their reasoning qualities were more sophisticated in high level. Finally, the teachers considered students' different points of view more frequently by performing more dialogic approach in high level. Although students were given more opportunity to offer different points of view in high level, students had still difficulty in using evidence and rule-based reasoning while supporting their claim. Then, the recommendations for PD program are given about how teachers create classroom discourse for increasing students' reasoning quality.

Keywords: Classroom Discourse, Argument-Based Inquiry, Reasoning Qualities of Students, Sociocultural Perspective, Quality of Argument-Based Inquiry Implementation

ÖZ

FEN BİLİMLERİ ÖĞRETMENLERİNİN SINIF SÖYLEMLERİNİN VE ÖĞRENCİLERİN AKIL YÜRÜTME KALİTELERİNİN ARGÜMANTASYON TABANLI BİLİM ÖĞRENME YAKLAŞIMI DOĞRULTUSUNDA İNCELENMESİ

Gülşah, Özkan İnal
Yüksek Lisans, İlköğretim Fen ve Matematik Alanları Eğitimi
Tez Yöneticisi: Prof. Dr. Özgül Yılmaz-Tüzün

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Bu çalışmanın üç amacı bulunmaktadır. İlk olarak, orta ve yüksek düzey Argümantasyon Tabanlı Bilim Öğrenme (ATBÖ) uygulamalarında öğretmenlerin söylemsel hamleleri araştırılmıştır. Ayrıca farklı uygulama seviyelerinde öğrencilerin muhakeme kalitesi ve öğretmelerin söylemsel hamleleri arasındaki ilişki incelenmiştir. Son olarak, öğretmenler tarafından gerçekleştirilen iletişimsel yaklaşım türleri incelenmiştir. Bu çalışmanın katılımcıları iki ortaokul fen bilimleri öğretmenidir. Bu öğretmenler mesleki gelişim programına katılan öğretmenler arasından amaçlı olarak seçilmiştir. Katılımcı öğretmenlerin öğrencileri de bu çalışmaya dahildir. Bu çalışmanın veri kaynağı ATBÖ uygulamalarının video kaydıdır. Veriler sistematik gözlem aracılığıyla analiz edilmiştir. Bu çalışma, yüksek düzey ATBÖ uygulamalarında öğretmenlerin daha fazla yansıtıcı söylem gerçekleştirdiğini ve daha az bilgi sağladığını ve öğrenci cevabını değerlendirdiğini göstermiştir. Bununla birlikte öğretmenler her iki uygulama düzeyinde bazı hamleleri (çeldirme ve delillendirme) sergilemekte zorluk çekmişlerdir. Öğretmen hamlelerindeki (bilgi sağlama ve değerlendirme ve yansıtıcı söylem) değişim öğrencilerin artan muhakeme kalitesi ile ilişkidir çünkü öğrencilerin akıl yürütme kalitesi yüksek düzey uygulamada daha sofistikedir. Son olarak, yüksek düzey uygulamada öğretmenler daha fazla diyalojik yaklaşım sergileyerek öğrencilerin farklı fikirlerini daha çok dikkate almıştır. Yüksek düzey uygulamada öğrencilere farklı fikirlerini ifade etmeleri için fırsat verilmesine rağmen, öğrenciler iddialarını delil ve kural temelli desteklemekte zorluk yaşamışlardır. Öğrencilerin akıl yürütme kalitesini arttırmak için nasıl sınıf söylemi oluşturulabileceğine dair öneriler mesleki gelişim programları için sunulmuştur.

Anahtar Kelimeler: Sınıf Söylemi, Argümantasyon Tabanlı Bilim Öğrenme, Öğrencilerin Akıl Yürütme Kalitesi, Sosyokültürel Perspektif ve Argümantasyon Tabanlı Bilim Öğrenme Uygulamalarının Kalitesi

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LIST OF ABBREVIATIONS

ABI	Argument-Based Inquiry
EBR	Evidence-Based Reasoning
MONE	Ministry of National Education
NRC	National Research Council
PD	Professional Development
TDMs	Teacher Discursive Moves

CHAPTER 1

INTRODUCTION

Given the necessities of inquiry-based science education, research has highlighted the importance of active involvement of students in the classroom discourse where they generate their claims, support them with evidence, present rebuttal for them and challenge their peers' ideas instead of just conducting their investigation (Driver, Newton & Osborne, 2000; Lehrer & Schauble, 2006; Sampson, Grooms, & Walker, 2010). The effective classroom discourse not only allows students to be involved in interactions with their peers and teacher but also fosters students' conceptual understanding (Candela, 2005; Chin 2007; Molinari & Mameli, 2013). The traditional classroom mostly includes the IRE (initiate-response-evaluation) triadic pattern of interaction where the teacher probes questions, students respond then the teacher evaluates their response against canonical knowledge of science, in turn causes little interactions among students (Macbeth, 2003; Mehan, 1979) and the teacher talk dominates the classroom discourse (Alexandar, 2005; Crawford, 2005; Mercer, Dawes, & Staarman, 2009; Wells & Arauz 2006). However, the inquiry-based science classroom involves various patterns of interaction to support students' involvement rather than only triadic patterns of interaction (McNeil & Pimentel, 2010). The roles of teacher in providing effective classroom discourse have been increasingly investigated in the education literature (Smart & Marshall, 2013).

The definition of discourse is accepted as the usage of language in social context (Gee, 2001). Moreover, classroom discourse is beyond the classroom talk, it involves interplay between students, teachers and these people's viewpoints (Smart & Marshall, 2013). In the field of education, investigation of classroom discourse has been mostly conducted within the Vygotsky's sociocultural perspective of learning and development (Scott, 1998). This perspective was adopted in this study. Based on this perspective, conceptual understanding happens in both individual (intrapsychological) and social (interpsychological) planes (Vygotsky, 1978). While learners present their points of view through language and other semiotic mechanisms on the social plane, learners internalize these views on the individual plane. In other words, learning occurs first on the social plane, then inside of the learners (Vygotsky 1978). From this point, language plays an important role in students' learning and thinking processes. Vygotsky's perspective underlines the significance of classroom discourse on the social plane for the students' conceptual understanding, especially the interaction between teacher and students in the classrooms (Scott, 1998). As the heart of Vygotsky's sociocultural perspective, the concept of teachers' scaffolding through zone of proximal development (ZPD) emphasizes the importance of teacher's role in the classroom discourse (Mortimer & Scott, 2003; Scott, 1998). The roles of a teacher as scaffolding can include discursive moves that might be wholly verbal (mimics, gestures, body posture, tone of voice) and non-verbal (verbalization) behaviors. This study investigated teachers' discursive moves (TDMs) performed by teachers on the social plane of science classroom in the context of Argument-Based Inquiry (ABI) implementation.

1.1. Classroom Discourse and Teachers' Discursive Moves

Scott (1998) categorized classroom discourse as authoritative and dialogic considering the characteristics of teacher utterances, student utterances and classroom discourse. In the authoritative classroom discourse, teachers have a tendency to transmit information. In this sense, authoritative TDMs can be giving information (Scott, 1998), evaluating students' ideas by accepting or rejecting them (McMahon, 2012), summarizing students' ideas that are discussed earlier (van Booven, 2015), asking questions that have just one true scientific answer in teachers' minds (Mortimer & Scott, 2003; Scott, 1998) and interrupting students' answer before students do not complete their sentence (Chin, 2006). In the dialogic classroom discourse, teachers give students opportunities to extend their ideas as well as discover different views. In this respect, the dialogic TDMs can be asking for clarification, probing students' idea, focusing particular idea in order to get attention, asking students to monitor classroom, throwing responsibility of thinking to students (van Zee & Minstrell, 1997b), challenging and asking students for justifying their ideas (Simon, Erduran & Osborne, 2006). Wertsch and Toma (1991) indicated that "the styles of interpsychological functioning employed in classroom discourse will be reflected in subsequent intrapsychological functioning" (p. 171). Thus, the feature of classroom discourse has an impact on the quality of student's thinking process on the individual plane. Some studies in the field of classroom discourse have a tendency to underline the important role of dialogic classroom discourse in supporting student-centered learning and teaching instead of authoritative discourse (Alexander, 2006; Chin, 2006, 2007; Martin & Hand, 2009; van Zee & Minstrell, 1997a, 1997b). On the other hand, some other studies suggested that there must be a balance between utilizing authoritative and dialogic approaches depending on the students' outcome aimed by the lesson (Aguiar, Mortimer & Scott, 2010; Mortimer & Scott, 2003; Nassaji & Wells, 2000; Nurkka, Viiri, Littleton, & Lehesvuori, 2014; Scott, Mortimer & Aguiar, 2006). In other words, for the meaningful understanding of scientific concepts and meaning making in the classroom, applying both authoritative and dialogic discourse approaches is essential because authoritative discourse enables "continuity and the reliable transmission of culturally valued content" while dialogic discourse "encourages creativity and allows for innovation" (Sedova, Sedlacek & Svaricek, 2016, p. 15). In this study, both dialogic and authoritative teachers' discursive moves were investigated during ABI implementations.

The in-depth analysis of teacher discursive moves is important for understanding how teacher intervenes for the meaningful learning in the classroom discourse. However, Mortimer and Scott (2003) argue that disadvantages of this kind of micro analysis is getting lost in detail of teacher discursive moves and not to taking holistic approach to the classroom discourse. For a better understanding of the classroom discourse, communicative approaches enacted by teachers were investigated in this study. As the central component of the Mortimer and Scott's (2003) framework, communicative approach analyzes whether the students' points of view are considered or not and the interactions between students and teacher are happening or not in science classrooms. Therefore, the classroom discourse has two dimensions; interactive/non-interactive and dialogic/authoritative. In other words, ideas' exchange in the discourse does not mean that different students' ideas are taken into account by the teachers. While none of the communicative approach is not bad or good, the effective use of communicative approach should depend on the purpose of the teacher's instruction (Aguiar et al., 2010; Mortimer & Scott, 2003; Scott et al., 2006). Lehesvuori (2013) maintains that in the communicative approach, there is no one teacher or student utterance or an interaction of student-teacher. Communicative approach includes a range of teacher-student interaction depending of the aim of the science lesson. Therefore, the communicative approach enacted by teachers is analyzed regarding dominant feature of patterns of teacher-student interactions. In other words, communicative approach can be determined considering the episode of the lesson while dialogic and authoritative discursive moves are determined considering the teacher utterance. In this study, the use of communicative approach was investigated in the context of ABI approach. Since the ABI approach has different phases, the teacher had better use a different communicative approach for the meaning making.

1.2. Teachers' Discourse Moves and Students' Cognitive Contributions

Researches showed that there was a relationship between teacher's discursive moves and students' cognitive contributions. In the field of classroom discourse, the cognitive contribution of students was explored in both quantitative and qualitative ways. Students' quantitative contribution was explored in terms of the length of students' answers and the proportion of student talk in classroom discourse (Soysal & Yilmaz-Tuzun, 2019). Moreover, the quality of students' cognitive contributions was investigated with respect to cognitive pathways, argument structure as well as quality of reasoning. Previous studies mostly studied on the impacts of teacher questioning on students' cognitive contribution (Soysal & Yilmaz-Tuzun, 2019). Research (e.g. Erdogan & Campbell, 2008; Smart & Marshall, 2013; van Zee & Minstrell, 1997b) showed that the open-ended questions were directly related to the students' cognitive contribution. For instance, Martin and Hand (2009) and McNeill and Pimentel (2010) stated that there was a relationship between students' questioning strategies and students' usage of argumentation structure. They also concluded that the open-ended questions of teacher increased student voice that can be described as the chance for students to be involved in interaction with their teacher and peers. As the student voice increases in the classroom discourse, quality of argument structure, such as making claims, offering strong evidence for their claims and providing rebuttals increases (Martin & Hand, 2009; Mercer, Dawes, Wegerif & Sam 2004; Naylor, Keogh & Downing, 2007). This being the case, quantitative increase in students' contribution (student voice) can bring about qualitative increase in cognitive contribution of students (student' argumentation structure) (Soysal, 2017). On the other hand, Boyd and Rubin (2006) suggest that contingent questioning that probes students' response increases students' cognitive skills rather than the structure of questions (open-ended and closed-ended questions). In other words, all open-ended questions do not trigger students' cognitive processes, while all close-ended questions do not limit students' contribution. Some studies explored the impact of discursive moves on students' cognitive contribution instead of just looking into teacher questioning. Pimentel and McNeill (2013) concluded that the use of authoritative discursive moves, such as cut-off, caused the short students' responses that did not involve reasoning while these types of moves were essential for the epistemic and social framing of lesson. However, reflective discourse that requests students to evaluate peer's responses enables students to demonstrate higher-order cognitive process (van Zee & Minstrell, 1997a).

Some studies focused on the potential role of third moves of teacher in the IRF (initial, response and feedback) interaction patterns on triggering students' cognitive contribution. For instance, Chin (2006) found that when teachers avoided evaluating and restating students' response in the third move of IRF sequence, students could use higher order thinking process such as "hypothesizing, predicting, explaining, interpreting, and making conclusions" (p. 1321). Similarly, van Booven (2015) contended that while dialogic moves gave students an opportunity to show high cognitive process, authoritative moves restricted students' cognitive process. In the national literature, there were few studies that investigated the relationship between teacher discursive move and students' cognitive contribution. In this study, the relationship between TDMs and student's reasoning quality as students' cognitive contribution was investigated. Students' reasoning quality was determined by using Evidence-Based Reasoning Video Framework (EBR Video Framework) (Furtak et al., 2010). This framework determines as to what extent students' claim has been supported during ABI implementation.

1.3. Argument Based Inquiry in Science Education

The meaning of learning science is that students have the ability to talk science, which needs participation of students in talking science (Lemke, 1990). This offers that students should be given the opportunity to be involved in classroom discourse where they experience talking science such as justifying, evaluating and challenging (Driver, Newton, & Osborne, 2000; McNeill & Pimentel, 2010). Scientific argumentation promotes students' involvement in authentic science discourse through offering their reasons for justifying their claims and challenging the ideas with their peers and teachers through negotiation (Driver et al., 2000; Ford, 2008). Students involvement in the argumentation allows them to experience cognitive, social, and epistemic components of scientific practices, which in turn, improves their comprehension of the knowledge construction in scientific community (Jimenez-Aleixandre & Crujeiras, 2017; Osborne, 2010). In other words, the process of argumentation enables students to find out science as a means of knowing (Cavagnetto, 2010; Driver, Newton, & Osborne, 2000; Duschl & Osborne, 2002; Duschl, 2008; Erduran & Jimenez-Aleixandre, 2007; Millar & Osborne, 1998) In addition, argumentation promotes students' reasoning skills and conceptual understanding of science (Jimenez-Aleixandre & Pereiro-Munhoz, 2002; Furtak et al., 2010; Sampson et al., 2011; Nussbaum & Sinatra, 2003; von Aufschnaiter, Erduran, Osborne, & Simon, 2005; Zohar & Nemet, 2002). In this manner, teachers should understand how they integrate argumentation into their classroom and develop their pedagogical practices that promote effective argumentation implementation in their classroom.

Argument-based interventions have been consistently increased in science education literature due to the recognition of significant role of argument (Cavagnetto, 2010; Soysal & Yilmaz-Tuzun, 2019). Cavagnetto (2010) broke down the argument-based interventions into three; 1) explicit approach 2) immersion approach 3) socioscientific approach. Although all three types of interventions aim to increase student's scientific literacy by means of argument, the structures of argument are taught in different ways. Among the three types of argument-based approaches, the immersion approach was selected because of two reasons for the context of this study. The first reason for choosing immersion intervention was the way of learning using scientific language. The structures of argument are explicitly taught before the usage of argument in the explicit approach. However, according to the perspective of "language as a learning tool" (Gee, 2004), learning of using language is not isolated from learning science (Cavagnetto & Hand, 2012). In the immersion approach, structures of arguments are embedded in the scientific inquiry that asks students to collect data, make claim based on evidence, justify their idea (Cavagnetto & Hand, 2012; Keys, Hand, Prain & Collins, 1999). In other words, students are required to utilize structures of argument which are an important aspect of construction of scientific knowledge. Therefore, immersion approach best meets the needs of scientific literacy through doing inquiry (Cavagnetto & Hand, 2012). The second reason was the perception of immersion approach towards the structure of arguments. While prepared arguments are presented to students for using them in the explicit approach, students are involved in scientific investigation in order to make their claim based on evidence in the immersion approach. This means that immersion intervention allows students to be engaged in cognitive process. Since this study examined the students' cognitive contribution considering the language as a way of learning, immersion approach was used. The immersion approach was used because of these reasons in other studies (e.g., Soysal, 2017; Soysal & Yilmaz-Tuzun, 2019).

As one of the immersion approaches, ABI was used for the context of this study. ABI approach includes language, argumentation, and inquiry (Hand & Keys, 1999). This means that students are involved in scientific investigation as a scientific community in which they use scientific language through oral and written argumentation (Cavagnetto et al., 2010). ABI approach allows students to be engaged in the cycles of negotiation and argumentation in the small group and whole class discussion where students make claims, justify their claims with evidence as wells as negotiate their claims with their peers and teachers during science activities (Akkus, Gunel & Hand, 2007; Hand, Norton-Meier, Gunel & Akkus, 2016; Hand & Keys, 1999; Milar &

Osborne, 1998; Nam, Choi & Hand, 2011; Siegel, 1995). Moreover, research showed that ABI had a positive effect on students' conceptual understanding of science concepts (Hohenshell & Hand, 2006; Keys et al., 1999) and students' cognitive process (Grimberg, Mohammed, & Hand, 2004; Kılıç, 2016; Martin & Hand, 2009).

Teacher's pedagogical strategies are associated with the quality or level of ABI implementation (Benus, Yarker, Hand & Norton-Meier, 2013; Kılıç 2016; Omar & Hand, 2004; Yesildag-Hasancebi & Kıngır, 2012). In order to determine the implementation level of ABI, Reformed Based Observation Protocol (RTOP) has been commonly used in the literature (Lund et al., 2015). RTOP developed by Piburn et al. (2000) and modified align with ABI by Martin and Hand (2009) is an instrument the extent to which the main characteristics of reform-based science education standards are reflected in science classroom (Piburn & Sawada, 2000). Within the scope of this study, RTOP scores of teachers were classified as medium and high level of ABI implementation. However, although the score of RTOP is related to the quality of ABI implementation (Cavagnetto et al., 2010; Martin & Hand, 2009), factors that differentiate between different implementation levels should be closely examined and described (Benus et al., 2013). The teachers' implementation level of ABI approach was examined with respect to teachers' discursive moves, patterns of classroom interaction and the cognitive contribution of students. It was found that when teachers moved toward high-level of ABI implementation approach in science classroom, they asked more open-ended questions that triggered students' reasoning and elaborated on their previous response (Kim & Hand, 2015; Martin & Hand, 2009). Moreover, Benus et al. (2013) showed that while low-level implementation included IRE pattern that little opportunity was given for students' reasoning, high-level implementation emphasized the evidence-based reasoning of students. Research revealed that the quality of ABI implementation increased, students' conceptual understanding (Akkus et al., 2007; Gunel, 2006; Omar & Hand, 2004), the quality of students' scientific argument (Martin & Hand, 2009; Omar & Hand, 2004); the benefit of low-achieving students (Akkus et al., 2007), students' reasoning level (Kim & Hand, 2015) and learning of multimodal representation (Demirbag & Gunel, 2014) improved in science classrooms. There is a need to investigate the processes how teachers move toward the higher implementation level of ABI in science classroom by comparing teachers' discursive moves in a detailed way (Kim & Hand, 2015; Pinney, 2014). This comparison also sheds light on how classroom discourse has changed through teachers' progression toward ABI teaching. In this study, the differences between discursive moves in teachers' medium and high level of ABI implementation have been investigated.

Studies (e.g., Kazemi & Hubbard 2008) have suggested that teachers need a PD program in order to promote classroom talk for meaning making. Additionally, the characteristic of PD program is an important factor for the teachers' pedagogical changes. Moreover, the features of PD programs are different in the research of classroom discourse. Desimone (2009) identifies five characteristics of effective PD program in order to develop teacher's pedagogy: "(1) content focus: activities that are focused on the subject matter content and how students learn that content; (2) active learning: opportunities for teachers to observe, receive feedback, analyze student work, or make presentations, as opposed to passively listening to lectures; (3) coherence: content, goals, and activities that are consistent with the school curriculum and goals, teacher knowledge and beliefs, the needs of students, and school, district, and state reforms and policies; (4) sustained duration: PD activities that are ongoing throughout the school year and include 20 hours or more of contact time; and (5) collective participation: groups of teachers from the same grade, subject, or school participate in PD activities together to build an interactive learning community" (Desimone & Garet, 2015, p. 253). Similarly, Darling-Hammond, Hyler and Gardner (2017) emphasized that the changes in teacher practice were not achieved in a short session called "one-shot session, sit-and get and one size fits all approaches" by Budde (2011, p. 21).

Moreover, in the literature, teacher's pedagogical progression was investigated in the short-term PD program (Benus et al., 2013). It is seen that effective PD program has to be considered as a process rather than an event (Loucks-Horsley et al., 1987, 1998). Moreover, the progression of teacher pedagogy can be viewed as a continuous and an ongoing effort (McLaughlin & Marsh, 1978). In this respect, in the related literature, it is a need to explore teachers' pedagogical progression in a longitudinal and sustained PD program.

In this study, participant teachers were involved in a 3-year long PD program funded by the Scientific and Technological Research Council of Turkey (TUBITAK). Within the scope of this program, teachers participated in-service teacher training at the beginning of each semester. During the trainings, teachers were given the opportunity not only to experience implementation of ABI as a learner, but also to be involved in pedagogical discussion about the implementation with respect to teaching and learning. Moreover, teachers conducted a unit preparation to implement ABI in their classroom during the training. Through the PD program, teachers were given on-going support before, during and after their classroom implementation to overcome their difficulties in classroom implementation. Overall, the PD program met the five characteristics of effective PD program identified by Desimone (2015).

1.4. Argument Based Implementation within Different Science Contents

In this study, the participant teacher conducted ABI implementation within different science contents. The science contents are related with the students' involvement in argumentation discourse (Sadler, 2006). Moreover, the learning demand of each science concept is different (Leach & Scott, 2002). Students' everday language of science is referred to as "alternative conception" or "misconception". Students' alternative conceptions about science concepts can be derived from teachers' insufficient content knowledge (Sadler & Sonnert, 2016), teachers' discursive moves (McNeil & Alibali, 2005), inadequate explanation of concepts in textbook (Ault, 1984; King, 2010), and their social language of science (Mortimer & Scott, 2003). In this study, the relationship between teacher discursive moves and reasoning quality in different science content was examined considering the current literature about students' understanding of science concepts. Moreover, the contents of science topics were as follows: buoyancy, sound, reproduction, growth and development in human as well as electrical conductivity in this study. In the concept of sound, students have misconceptions about the concepts such as speed of sound, intensity of sound, frequency of sound, height of sound in elementary level (Beaty, 2001). As regards of buoyancy force, concepts of floating and sinking cause misunderstandings, for instance, students in elementary level relate the reasons of objects' floating and sinking to only its mass, shapes, volume and objects with holes (Pine, Messer & John, 2001). Moreover, students in elementary level have difficulty in learning electricity since the concepts of electricity are abstract for them. Regarding Reproduction, Growth and Development in Human, teachers have difficulty in teaching because of the abstract concept and perceiving the concept as a shameful (Yagcioglu, 2015).

1.5. Purpose of the Study

The main purpose of this study was to investigate science teachers' classrooms discourse in ABI approach and students' reasoning. In order to address the aim of this study, teachers' discursive moves were investigated in medium and high level of ABI implementations by using catalog of teacher discursive moves. Therefore, the fluctuations among discursive moves (TDMs) performed by teachers in different levels of ABI implementations were explored. As far as the classroom discourse was concerned, the communicative approaches performed by teachers in medium and high level of ABI implementations were explored. Then, this study aimed to examine the relationship between TDMs and students' reasoning qualities.

1.6. Research Questions

This study addresses the following questions:

1. What are the discursive moves (TDMs) performed by teachers in the medium and high levels of ABI implementation?
2. What are the communicative approaches performed by teachers in the medium and high levels of ABI implementation?
3. What is the relationship between teachers' discursive moves and students' reasoning quality in medium and high levels of ABI implementation with different science contents?

1.7. Significance of the Study

Although the importance of argumentation in science education has been emphasized by the national and international reform movement (Ministry of National Education [MoNE], 2005; National Research Council [NRC], 2007, 2012; Organisation for

Economic Co-operation and Development [OECD], 2003), it is rarely found in science classroom (Cavagnetto et al., 2010; Driver, Newton, & Osborne, 2000; Newton, Driver, & Osborne, 1999). Moreover, teachers have difficulties in shifting their practices towards argument-based inquiry approach. This study gives information to teachers about type of discursive moves in different levels of ABI implementation. In education literature, the factors determining quality of ABI implementation are not investigated in detail. There is a need to investigate changes in discursive moves through their pedagogical progression toward inquiry-based approach (Benus, 2011, Kim & Hand, 2015, Pinney, 2014). The quality of ABI is associated with teacher questioning, student voice and science argument (Martin & Hand, 2007). Additionally, these criteria are determined considering theoretical research rather than looking at what actually happens in the classroom (Pinney, 2014). In this study, classroom discourse as a factor of determining quality of ABI is deeply analyzed through in-depth and fine-grained sense. In this study, the changes in the frequency and percentages of occurrence of TDMs in the medium and high level of ABI implementation were been explored in detail. Therefore, this study was designed to provide insight to the changes of teacher discursive moves as teachers move toward high implementation level of ABI approach. Therefore, this study contributes to the content of PD program in order to improve teachers' classroom discourse with respect to criteria that affects the quality of implementation level of ABI.

In the literature, some researchers claim that the quality of ABI implementation is associated with the dialogic discourse, others claim that teachers should conduct both dialogic and authoritative discourse for the meaning making in science classroom (Alexander, 2006; Mortimer & Scott, 2003). Within the framework of this study, the quality of ABI implementation was also investigated with respect to types of communicative approach along two dimensions: interactive-non-interactive and dialogic-authoritative. This study argues about the fluctuation among communicative approaches performed by teacher in different level of ABI implementation.

It has been emphasized that students should use evidence to support their scientific argument in scientific discourse (National Research Council [NRC], 1996, 2001, 2007). In science classroom discourse, high level of reasoning is solely found out. In other words, students usually do not support their claim based on evidence in science classroom (Osborne, Erduran, & Simon, 2004; Newton & Newton, 2000). Studies reveal that teachers do not have enough pedagogical tools that support students' evidence-based reasoning. Thus, this study aims to inform teachers and teacher trainers about the relationship between teacher's discursive moves and quality of students' reasoning. When teachers realize the importance of their discursive moves on student reasoning quality, they may put emphasis on their discursive moves in their classroom. The result of this study also sheds light on the content of PD program in terms of the consideration of the relationship between teacher discursive moves and students' cognitive contribution.

As a reminder, the aim of this study was to investigate fluctuations across teacher discursive moves and communicative approach in medium and high level of ABI implementation. Teachers in this study were involved in a 3-year PD program that aimed to increase teachers' pedagogical understanding and skills of ABI implementation. During the program, teachers were given on-going support to increase the effectiveness of the ABI implementation. Various quality of ABI implementation happened within 3-year PD program. To this end, the implementations of the teachers were selected from 18th month and 24th months of the PD program. Researchers (Huberman & Miles, 1984; Martin & Hand, 2009) have argued that the change in teacher practice happens after 18 months. On the other hand, the short-term PD program is common in the studies that focus on developing teachers' practices (Adey, 2006; Lieberman, 1995; Shibley, 2006). As mentioned above, this study was conducted within the context of the longitudinal PD program. In this respect, it sheds light on the change in classroom discourse of teachers within the longitudinal PD program regarding difficulties that encounters towards pedagogical progression.

1.8. Definition of Terms

Argument Based Inquiry (ABI): Argument Based Inquiry is an immersion intervention of science argumentation (Cavagnetto, 2010). In addition, ABI is a teaching approach that embeds scientific argumentation in the investigative context by means of semiotic tools (Nam, Choi & Hand, 2010).

Teacher Discursive Moves (TDMs): Teacher discursive moves are described as communicative tools that provide meaning making of science concepts to students (Leach & Scott, 2002). Teachers' discursive moves might be wholly verbal (mimics, gestures, body posture, tone of voice) and nonverbal (verbalization) behaviors enacted by the teacher. In this study, teachers TDM is examined with the catalogue of TDMs that consists of nine main categories.

Communicative Approach: Being the core of the framework, communicative approach concerns the ways that teachers work with students in order to deal with students' idea during the classroom discourse. The four main types of communicative approach have been defined with respect to two dimensions; *dialogic-authoritative* and *interactive-noninteractive.*

Teacher's Implementation Level of ABI: It refers to the quality of ABI implementation in this study. The overall RTOP scoring between 2 and 3 equals to medium level of ABI implementation, while the overall RTOP scoring between 3 and 4 equals to high level of ABI implementation.

Sociocultural Perspective of Learning: According to Vygotsky (1978), learning occurs in both social and individual levels. Vygotsky (1931) indicates that "Any function in the child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane. First it appears between people as an interpsychological category, and then within the child as an intrapsychological category. This is equally true with regard to voluntary attention, logical memory, the formation of concepts, and the development of volition. We may consider this position as a law in the full sense of the word, but it goes without saying that internalization transforms the process itself and changes its structure and functions. Social relations or relations among people genetically underlie all higher functions and their relationships." (p. 163).

CHAPTER 2

LITERATURE REVIEW

The main purpose of this study was to investigate the classroom discourse in the teachers' medium and high levels of Argument Based Inquiry (ABI) implementations. In this sense, this chapter will first review the perspectives of argumentation, the place of argumentation in science education and the types of argument-based approach. Then, as the context of this study, one of the immersion approaches, ABI and studies on ABI will be explained. After that, sociocultural perspective of Vygotsky will be discussed in terms of learning and teaching. Then, the importance of teacher discursive moves (TDMs) in a classroom discourse and the relationship between students' cognitive contribution and TDMs will be explained. Eventually, the teacher PD program needed for improving classroom discourse will be discussed.

2.1. Argumentation

2.1.1. Argumentation as a Social and an Individual Process

Argumentation occurs at both an individual and a social level (Jimenez-Aleixandre & Erduran, 2008; McNeill & Pimentel, 2010). At the individual level, individuals construct their knowledge claims based on evidence through reasoning (Driver et al., 2000; McNeill, 2009). The argumentation may take place within an individual through writing or talking (McNeill & Pimentel, 2010). At the social level; however, argumentation involves social interaction between individuals where they struggle to convince each other about the validity of their claims by challenging and criticizing each other's claims and evidences (Berland & Reiser, 2011). Social level of argumentation allows students to develop their higher level of thinking skills which are required to enhance students' conceptual understanding. From these points of view, both individual and social levels of argumentation are required in the classroom discourse since argument is constructed at the individual level, and then, the meaning is negotiated at the social level. On the other hand, van Eemeren and Grootendorst (2004) emphasize only the social meaning of argumentation by saying "argumentation is a verbal, social and rational activity aimed at convincing a reasonable critic of the acceptability of a standpoint by putting forward a constellation of propositions justifying or refuting the proposition expressed in the standpoint" (p. 1). According to this point of view, argumentation is considered as persuasion without considering an individual cognitive process. However, Fords (2008) agrees with the idea that argument is both constructed by individual and constructed and social interaction which takes places through negotiation. If the individual and social aspects of argumentation are not included in the inquiry-based instruction, students may not be involved in learning science (Jimenez-Aleixandre & Erduran, 2009). In science education, students not only need to have the ability to build their claims but also, they require to challenge with peers' claims within the social context (Jimenez-Aleixandre & Erduran, 2008; McNeill & Pimentel, 2010). Thus, in this study, argumentation in science learning environment included both the individual and social levels. In addition to aspects of argumentation, there are two frameworks on the role of the argumentation discourse in science classrooms (Jimenez-Aleixandre & Erduran, 2008). The first framework emphasizes that argumentation discourse plays a significant role in the construction of knowledge in the science classrooms (Knorr-Cetina, 1999; Latour & Woolgar, 1986). Based on the sociocultural perspective (Vygotsky, 1978; Wertsch, 1991), the second framework indicates that construction of knowledge occurs through social interaction between and within learners. This social interaction enables the ways for individual thinking through the means of language. In this study, a second framework was adopted. This framework also implies that argumentation happens at an individual and a social level.

2.1.2. Argumentation as a Core Element of Science Education

The international and national organizations have underlined the significance of argumentation in science education (Australian Curriculum, Assessment and

Reporting Authority [ACARA], 2009; National Research Council [NRC], 2007, 2012; Ministry of National Education [MoNE], 2005, Organization for Economic Co-operation and Development [OECD], 2003; U.K. Department for Children, Schools, and Families [DCSF], 2009). Moreover, most of the researchers (e.g., Driver, Newton, & Osborne, 2000; Duschl, 2008; Jimenez-Aleixandre & Erduran, 2008; Hand, Yore, Jagger, & Prain, 2010; Kuhn, 1993; Kuhn, 2010; Osborne, Erduran, & Simon, 2004) offer that argumentation is an essential practice in the science classroom for students' construction of knowledge as well as the comprehension of the epistemic nature of science and science literacy.

Scientific argumentation is the core activity within the scientific community. Jiménez-Aleixandre and Erduran (2008) indicate that argumentation enables students to understand the practices of scientists. For example, the Next Generation Science Standard (NGSS) (NRC, 2012) focuses on the importance of scientific argumentation by proposing that "engaging in argumentation from evidence about an explanation supports students' understanding of the reasons and empirical evidence for that explanation, demonstrating that science is a body of knowledge rooted in evidence" (p. 44). Similarly, the students' involvement in epistemic, social and cognitive aspects of argumentation allows them to understand how knowledge is constructed in the scientific community (Osborne, 2010). In addition, Driver et al. (1998) state that learning science should provide students with an opportunity to understand the epistemology of science and nature of science as a process of social construction of knowledge through conceptual understanding of science. Therefore, scientific argumentation helps learners to understand epistemic nature of science. The students' ability to engage in scientific argumentation can be regarded as the indicator of the scientific literacy (Jimenez- Aleixandre, Rodriguez, & Duschl, 2000). That is why, it can be considered that students' practice of scientists is a tool to promote students' scientific literacy (Walker &Sampson, 2013). If argumentation is not included in the science teaching, students' construction and critique of knowledge are restricted (Ford, 2008). When students are involved in the argumentation, the form of student question may be "why" instead of "what". The form of "why questions" guides students to be involved in the practices of scientists (Bricker & Bell, 2008). Additionally, scientific argumentation encourages students to talk and write the scientific language as a tool for learning science (Duschl & Osborne, 2002) Studies in the field of argumentation indicate that students' conceptual understanding of science improves during the interaction with others in the science classrooms (Promyod, 2013). Given that the argumentation is considered as a social and individual process, argumentation can be a significant social skill (Benus, 2011). The Organization for Economic Cooperation and Development (OECD, 2003) considers the practice of scientific argumentation as a life skill, which are the students' abilities to make claims from data, consider the validity of claims as well as critique peers' claims. While argumentation gives an opportunity for students to enhance their social interaction and communicative abilities, it enables students to promote higher order thinking and reasoning since students are given the chance to think on their claims (Clark & Sampson, 2007).

Erduran and Jiménez- Aleixandre (2018) state that argumentation has been explicitly emphasized in the national curriculum of most countries (e.g., Taiwan, Israel, Australia, Chile, United States, United Kingdom etc.). Especially, argumentation has been underlined as a method in the national Turkish science curriculum of middle schools:

1. The process of learning consists of exploration, inquiry, construction of knowledge, and product design. In addition, it is expected to give students opportunities that enable them to develop their communication and creative thinking skills by expressing themselves in written, oral and visual form.
2. Learning environments where students can discuss the advantages-disadvantages relationship about the scientific phenomena should be provided so that they can express their ideas, support their ideas for different warrants, and develop opposing arguments to refute their peers' claims. (MoNE, 2018, p. 11).

As seen above, Turkish curriculum emphasizes that learning environment should include scientific argumentation that asks students to make claims, justify them with evidence as wells as negotiate their claims with their peers and teachers through scientific reasoning, which is basically the practices of scientists. Moreover, the teacher role is described as improving students' scientific reasoning. In this sense, the role of teachers is important to create a learning environment that promotes argumentation for meaning making. Although the importance of argumentation in science education has been emphasized, argumentation has been rarely found in science classroom (Cavagnetto et al., 2010). Students have difficulty in supporting their knowledge claims with evidence rather than data, understanding the criteria of a good evidence as well as negotiating their peers' claims in the community (Cavagnetto et al., 2010; Martin & Hand, 2009, Sadler, 2004, Sampson & Clark, 2009). In addition, teachers experience difficulties in implementing argumentation with respect to lack of pedagogical skills and students' prior knowledge in their classrooms (Benus et al., 2013; Cazden, 2001; Hand, 2018; Osborne & Dillon, 2008).

The shift in teacher practice towards argumentation discourse requires to change classroom discourse towards learning environment where not only students voice is dominant in the classroom, but also, they are given the opportunity to negotiate the meaning (Crawford, 2000). In this study, the classroom discourse was examined in the different level of ABI implementation. In addition, the relationship between teachers' discursive moves and students reasoning quality was investigated in the argumentation discourse. The view of inquiry has been shifted from doing scientific experiment to engaging in argumentation where claims are constructed through the scientific investigation (Benus, 2011; Chin & Osborne 2010; Duschl et al. 2007). Given that argumentation should be placed in science classrooms, different teaching and learning instructions have been improved to integrate into science classroom by the science educator (Cavagnetto, 2010; Yun & Kim, 2015). In the following topic, the type of argument-based approach will be explained.

2.1.3. The Types of Argument Based Approach

In the review of Cavagnetto (2010), it has been found that there are three types of interventions with regard to the argumentative discourse: 1) *explicit approach*, 2) *immersive approach* and 3) s*ocio-scientific approach*. Although the argument structures are differently taught in all three argument-based approaches, these approaches aim to promote students' scientific literacy. In the explicit intervention, a structure of argument is explicitly taught, and students are requested to practice the structure in scientific contexts. In the IDEAS project (Erduran, Simon, & Osborne, 2004; Osborne, Erduran & Simon, 2004; Simon, Erduran, & Osborne, 2006), explicit intervention approach was used (as cited in Cavagnetto & Hand, 2012, p. 41). In this project, Toulmin's (1958) argument structure was taught to students and then students applied this structure to different science topics. In addition, the claims, evidence, and reasoning structure developed by McNeil and colleagues (McNeill, 2009; McNeill, Lizotte, Krajcik, & Marx, 2006; McNeill & Krajcik, 2008) were taught and applied by students (as cited in Cavagnetto & Hand, 2012, p. 41). Although different argument structures were utilized in these two studies, structures of argument were explicitly taught in both studies.

Secondly, in the socio-scientific instruction of science argumentation, interactions between society and science play important role in terms of the construction of the scientific argument. In this intervention approach, students are involved in the scientific argumentation through science-society-technology related contexts. For example, the issues of genetically modified foods, gene therapy, high-transmission power lines and construction of nuclear, power plants are studied in the socio-scientific interventions (e.g., Sadler, Chambers & Zeidler, 2004; Sadler & Donnelly, 2006, Sadler & Fowler, 2006, Walker & Zeidler, 2007; Wu & Tsai, 2007) (as cited in Cavagnetto & Hand, 2012, p. 42). Therefore, students are expected to negotiate the outcome of the application of scientific knowledge considering moral, ethical and political factors (Cavagnetto, 2010).

Finally, in the immersion approach, scientific argument is embedded in the scientific context. In other words, the immersion instruction helps students to construct arguments by means of scaffolding strategies (e.g., prompting questions, cognitive conflict and group collaboration). For instance, during ABI approach (Keys, Hand, Prain, & Collins, 1999; Martin & Hand, 2009), students are helped to construct argument through teacher questioning strategies. These questions seek to respond to students' research questions, claims, evidence and the differences and similarities between their and others' claim. Similarly, a computer program enables to scaffold in the study of Sandoval and colleagues (Sandoval & Millwood, 2005; Sandoval &

Reiser, 2004). Although there are various immersion-oriented approaches, argument is considered as embedded elements to scientific practice in all of these studies.

Cavagnetto (2010) also argues that these three approaches can be efficient for integrating argument into science classroom setting. However, while choosing types of argument-based interventions, the aims of the instruction should be taken into consideration. Among the three types of argument-based interventions, this study was carried out under the assumption of immersion approach. The first reason for choosing immersion approach among all argument-based approach was the perspective of immersion approach on using language. In the explicit approach, using language is learned before learning science (Halliday & Martin, 1993; Klein, 2006). That means that structures of argument are explicitly taught before students are involved in scientific activities. However, Gee (2004) argues that using language should be integrated into science learning because learning science is not separated from using language. Moreover, Hand and Prain (2006) recommend that the view of use of language as a learning tool has more benefits of learning outcome than the view of using language isolated form science learning. Therefore, although three different types of argumentation-based interventions support the scientific literacy, just immersion approach seems to provide culture that consists of epistemic nature of science as embedded in the practice of science (Cavagnetto, 2010). The significant role of the immersion approach is also emphasized that "the immersion orientation portrayed argument as a tool for both the construction and understanding of science principles and cultural practices (including discourse practices) of science." (Cavagnetto, 2010; p. 351). This being the case, the perspective of using language as learning science improves the understanding of epistemic nature of science and increases students' scientific literacy. The second reason was the perspective of immersion approach on introducing argument structure. In the explicit approach, students utilize structures of argument that their teachers present. However, in the immersion approach, students are asked to generalize their claim based on evidence through their scientific investigation. Therefore, students are engaged in higher level cognitive and social processes where they built their knowledge claims, and they support their claims with strong evidence. This study investigated students reasoning quality in the context of immersion approach. As one of the immersion approaches, ABI approach was used in this study as mentioned below in detail.

2.1.4. As an Immersion Approach: Argument Based Inquiry (ABI)

ABI approach is a langue-based argument approach that has been utilized as a way to create a scientific inquiry classroom by giving students an opportunity to negotiate and reflect on their reasoning for the construction of scientific knowledge (Driver et al., 1994, 2000; NRC, 1996). This approach helps students to improve conceptual understanding of science by means of using oral and written argumentation (Hand & Keys, 1999). The main difference between ABI and other types of inquiry is to what extent students are encouraged to critique not only their claims but also their peers' claims (Pinney, 2014). In the ABI approach, students are involved in inquiry activities in which argument structure is embedded (Keys et al., 1999). That is, students are required to utilize argument structures (question, claim evidence) as part of the construction of scientific knowledge. From this point of view, the argument structures are viewed as an inquiry rather than the product of the inquiry. In the context of ABI, language is considered as a learning tool rather than separating it from science learning (Gee, 2004). ABI approach is the junction point of language, argumentation and inquiry (Hand & Keys, 1999). As an essential component of science, language provides epistemic nature of science and science culture for students (Ford, 2008). Hand (2008) states that "language is a critical to the construction of science knowledge, the debate and argument of science, and the dissemination of science knowledge" (p. 1). The role of language in the learning is discussed.

Vygotsky's sociocultural perspective in the next section. This approach includes a range of scaffolding strategies, which ask students to utilize various types of language such as talking, reading and writing while they are involved in scientific investigation. ABI allows students to be engaged in the cycles of negotiation and argumentation where students make claims, justify them with evidence and negotiate their claims with their peers and teachers through science activities (Millar & Osborne, 1998; Siegel, 1995). Therefore, during the ABI approach, scientific argumentation is fulfilled with "the collaborative nature of scientific activity" (Hand et al., 2016, p. 850). To put it differently, in the ABI approach, students are involved in authentic science discourse (Newton, Driver, & Osborne, 1999). The ABI allows students to increase their conceptual understanding through negotiation with themselves, the group and the class (Driver, Newton, & Osborne, 2000). ABI approach also increases both social and cognitive skills as well as understanding of the epistemology of science (Hand et al., 2004).

ABI consists of two different components; student template and teacher template. As given in Table 1, as a learning tool, these templates help both students and teachers to be active and to interact with others during the scientific investigation (Burke, Greenbowe, & Hand, 2006). In the teacher template, there are various proposed activities in order to engage students in negotiation, writing and thinking about the scientific investigation (Keys et al., 1999). The teacher template serves a type of pedagogical tool for teachers in order to be prepared before implementing ABI approach in the class. During the preparation of implementation, teacher necessitates to complete the teacher template in order to guide negotiation in small and whole group.

Secondly, student template enables learners conduct to scientific investigation through question-claim-evidence. It leads students to conduct scientific investigation and reasoning through writing. The template encourages students to pose questions, make claims based on evidence within the context of the scientific investigation. Moreover, it gives students an opportunity to compare their claims with others (experts, peers, and information in the textbook) and to reflect upon how their ideas have changed. Overall, the student template leads students to conduct scientific investigation and to reason about their investigation. ABI offers alternative lab format different from traditional lab report that asks students to investigate the given questions and expected outcomes. While the relationship between question, claims and evidence is isolated from each other in traditional lab format, students are asked to connect them through negotiation and writing in the ABI approach, (Keys et al., 1999) which triggers students conceptual understanding through cycle of negotiation in small and whole group discussion as well as within themselves (Akkus et al., 2007).

Table 1. The Student and Teacher Template for ABI Implementation

Teacher Template	Student Template
1. Exploration of pre-instruction understanding through individual or group concept mapping.	1. Beginning ideas What are my questions?
2. Pre-laboratory activities, including informal writing, making observations, brainstorming, and posing questions.	2. Tests (What did I do?
3. Participation in laboratory activity.	3. Observations-What did I see?
4. Negotiation phase I-writing personal meanings for laboratory activity. (For example, writing journals.)	4. Claims-What can I claim?
5. Negotiation phase II-sharing and comparing data interpretations in small groups. (For example, making group charts.)	5. Evidence-How do I know? Why am I making these claims?
6. Negotiation phase III-comparing science ideas to textbooks for other printed resources. (For example, writing group notes in response to focus questions.)	6. Reading-How do my ideas compare with other ideas?
7. Negotiation phase IV-individual reflection and writing. (For example, creating a presentation such as a poster or report for a larger audience.)	7. Reflection-How have my ideas changed?
8. Exploration of post-instruction understanding through concept mapping, group discussion, or writing a clear explanation.	8. Writing- What is the best explanation that explains what I have learned

Note. Reprinted from "Introducing the science writing heuristic approach" by Hand, B., In B. Hand (Ed.), *Science inquiry, argument and language: A case for the science writing heuristic,* 2008, Rotterdam, The Netherlands: Sense Publishers.

Moreover, Driver et al. (2009) conclude that for promoting students to talk in the science classroom, practices of teachers must change from traditional approach to inquiry-based practices. Pedagogical shifts towards argument also need to change in the nature of classroom discourse. In the argumentation discourse, the role of teachers has to shift from knowledge providing to creating a learning environment that students comfortably express their ideas and negotiate with their teacher and peers. (Ladapat, 2002). Therefore, teachers necessitate to play various discursive moves that are not included in the traditional classrooms. Simon et al. (2006) determine the pedagogical moves enacted by teachers that may facilitate argumentation discourse in science classrooms. For instance, teachers encourage their students to justify their knowledge claims based on evidence, to discuss the validity of their claim with each other as well as to make reflection about whether their claims change or not to guide classroom discourse. This change in teacher practice emphasizes the use of evidence for making claims, forming criteria for judging validity of claims as well as the relation between claims and scientific theories (Erduran et al., 2005). Research showed that ABI approach had a positive effect on students' conceptual understanding in elementary and high school level (Akkus et al., 2007; Hand, Wallace, & Yang, 2004; Schroeder & Greenbowe, 2008), students' cognitive contribution with respect to cognitive pathways (Kılıç, 2016), their reasoning quality (Soysal, 2017; Soysal & Yılmaz-Tuzun, 2019) and their argument structure (Martin & Hand, 2009). Although there are quite a few studies on argumentation at the secondary and college level, few studies have examined the argumentation at the elementary level. In this study, the relationship between cognitive contribution of students and teachers' discursive moves was investigated in elementary science classrooms. On the other hand, teachers' pedagogical strategies can be an indicator as to what extent students' learning outcomes can be achieved through ABI implementation. The implementation level or quality of ABI approach is related to the teachers' pedagogy (Benus et al., 2013; Burke et al., 2006; Yesildag-Hasancebi & Kıngır, 2012; Kim & Hand, 2015). The level of ABI approach has been commonly evaluated by Reformed Based Observation Protocol (RTOP) developed by Piburn et al. (2000) and revised align with ABI by Martin and Hand (2009). The level of ABI implementation is evaluated with respect to teacher roles, students voice, scientific argument and the teacher questioning. Moreover, the implementation level or quality of ABI is parallel to the RTOP score (Cavagnetto et al., 2010; Martin & Hand, 2009). Studies revealed that the teachers' implementation levels of ABI became higher, the students' conceptual understanding (Gunel, 2006; Omar & Hand, 2004; Poock, Burke, Greenbowe & Hand, 2007; Mohammad, 2007), quality of scientific argument (Omar & Hand, 2004; Martin & Hand, 2009); the benefit of low-achieving students (Akkus et al., 2007) and learning of multimodal representation (Demirbag & Gunel, 2014) boosted in science classroom. For example, the implementation level of teachers is related to the teachers' ability to identify big ideas of the lesson, to pose open-ended questions and to involve students in dialogical interactions (Omar and Hand, 2004; Martin & Hand, 2009). However, there is a need to investigate differences in different implementation levels (Benus et al., 2013; Pinney, 2014, In this study, the fluctuations among the discursive moves and communicative approach in medium and high level were investigated. The analysis of the classroom discourse is often conducted under the assumption of Vygotsky's sociocultural perspective.

2.2. A Vygotskian Perspective on Teaching and Learning Science

In this study, Vygotsky's sociocultural perspective was adopted to examine the relationship between teacher discursive moves and students' reasoning quality in different level of ABI implementation. Therefore, in this section, Vygotsky's sociocultural perspective will be discussed with respect to learning and teaching.

2.2.1. A Vygotskian Perspective on Learning Science

According to Vygotsky (1978), learning occurs in both social and individual levels. Vygotsky indicates:

> Any function in the child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane. First it appears between people as an interpsychological category, and then within the child as an intrapsychological category. This is equally true with regard to voluntary attention, logical memory, the formation of concepts, and the development of volition. We may consider this position as a law in the full sense of the word, but it goes without saying that internalization transforms the process itself and changes its structure and functions. Social relations or relations among people genetically underlie all higher functions and their relationships. (Vygotsky, 1931, p. 163).

The main idea of Vygotsky's sociocultural perspective is that learning involves a journey from social plane to comprehension of the individual. In the social plane, a group of learners rehearses the ideas by means of language as well as various semiotic mechanisms that can be referred to as communication tools (symbols, diagrams, writing, gestures etc.) (Mortimer and Scott, 2003). In this study, the social plane comprised of teachers and their students in science classroom. Teacher discursive moves have a potential pedagogical tool for facilitating students' meaningful learning on the social plane. The semiotic mechanism utilized in the social exchange enables an individual to think. From this point of view, it is concluded that the learning occurs from *social* to *individua*l plane with social tools. The socio-cultural perspective has led researchers to examine the nature of interactions occurring in classrooms instead of focusing solely on students' learning outcomes (Lehesvuori, 2013; Lemke, 1990; Mortimer & Scott, 2003). This study investigated the relationship between students' reasoning quality as a students' cognitive contribution (individual plane) and teachers' discursive moves (interaction in social plane). Scott (1997) indicates “language is absolutely fundamental to thought and learning. It is not the case that language provides the means to communicate internally developed products of cognition; language provides the very means though which personal cognition occurs.” (p. 12). Therefore, language is considered as a tool that increases an individual's thinking (Lemke, 1990; Mercer, 1995). From the sociocultural perspective, there are three types of “scientific”, “everyday” and “school science” social languages (Mortimer & Scott, 2003). The everyday social language enables means of thinking and talking about the phenomenon that occurs around learners. Vygotsky (1987) defines the learners’ everyday social languages as a spontaneous conceptualization. For example, individuals usually talk about the concept of “rising and setting of sun” in everday social language. This way of talking allows to promote the view of sun moving across the space instead of the view of Earth rotating around the sun. The everyday social language consists of views that are called “*alternative conception*” as well as “*misconceptions*” in the literature (Mortimer & Scott, 2003). Therefore, everyday and scientific social language are different from each other. Moreover, real science conducted in the professional setting is different from school science performed in the school setting. The school science depends on social and political constraints and school science emphasizes the idea defined in the national curriculum (Mortimer and Scott, 2003).

2.2.2. A Vygotskian Perspective on Teaching Science

The main aspect of Vygotskian teaching perspective, zone of proximal development (ZPD), is defined by him 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 other” (Vygotsky, 1978, p. 86). The concept of scaffolding is the guidance given to learners through their ZPD (Mercer & Littleton, 2007). According to Bruner (1978) “[Scaffolding] refers to the steps taken to reduce the degrees of freedom in carrying out some task so that the child can concentrate on the difficult” (p.19). As a form of scaffolding, teacher discursive moves are the main components of classroom discourse to facilitate students' learning. In this study, the fluctuation among teachers' discursive moves in different implementation levels was investigated.

Science teaching can be viewed as introducing social language of school science (Leach & Scott, 2002). Moreover, the role of teacher is significant for introducing the social language of school science for students. Based on the Vygotskian perspective, in order to mediate meaningful learning, teaching sequence involves three important aspects: *staging the scientific story, supporting the student internalization* and *hanging over responsibility to the students.* The stage of teaching sequence is related to the phases of the ABI.

1) Staging the scientific story: The scientific points of views are referred as scientific story. The overall aim of this stage is that scientific story (i.e., the Buoyant Force) is made available to the whole class. Staging the scientific story involves the beginning interaction between students and teachers during ABI implementation (Soysal, 2017) as the context of this study.
2) Supporting student internalization: In this stage, teacher supports students to make sense of scientific points of views and internalize them. This stage is corresponded to the role of the teachers that supports students in the Vygotsky's notion of ZPD. While students conduct their scientific investigation, teachers scaffold the students' meaning making of the topic discussed before on the social plane of classroom within the ABI implementation (Soysal, 2017).
3) Hanging over responsibility to the students: Teacher enables students to apply scientific knowledge of the view for their internalization. In the whole group negotiation of the ABI implementation, student groups are engaged in the discussion where students support their claim with the evidence, challenge about their claims. This learning setting allows teachers to give responsibility of their own learning to them (Soysal, 2017).

2.3. Analyzing of Classroom Discourse

In education literature, studies focus on how conceptual understanding is developed through language and other communication tools (Scott et al., 2006). Various studies emphasize, from different perspectives, the significance of classroom discourse in science education (see, for example, Lemke, 1990, Mortimer, 1998; Mortimer & Scott, 2003; Scott, 1998). Classroom discourse moves beyond the classroom talk. It includes interaction between student-student, teacher-student as well as their points of view (Smart & Marshall, 2013). As mentioned above, in this study, sociocultural perspective of Vygotsky was adopted to examine the relationship between teachers' discursive moves and student's reasoning quality in different levels of ABI implementation.

Lemke (1990) analyzed the classroom discourse with respect to *thematic and organizational pattern.* The organizational pattern concerns how students and teachers interact with each other in a classroom discourse. In the pattern of interaction, the teacher begins with a question, the students respond, the teacher evaluates or poses a question on the student response, referred to as triadic dialogue. Triadic IRE (I stands for initiation- R stands for response-E stands for evaluation) is performed in the dialogue as teachers-student-teacher sequence (Mehan, 1979). Instead of giving evaluative feedback to students' responses, the teachers may ask follow-up questions in order to elaborate the students' response. This pattern of interaction corresponds to IRF sequence (F stands for feedback or follow-up) (Sinclair & Coulthard, 1975). In the current studies, pattern of interaction is commonly used and evaluated as a criterion in the comparison of changes in the classroom discourse (Benus, 2011). The patterns of interaction that appear in the science classroom are the consequences of the interaction between various variables. The aim and content of the lesson determine the teacher's instructional strategy, in turn, affects the pattern of interaction and teacher's contribution to the classroom discourse (Scott et al., 2006)

Moreover, Mortimer and Scott (2003) developed the framework related to the various aspects of the classroom discourse in order to analyze and characterize how teachers guide the classroom talk to promote student learning in science classrooms. The framework is based on Vygotsky's sociocultural perspective and is developed through longitudinal teacher PD program (see, e.g., Mortimer, 1998; Mortimer & Scott, 2000; Scott, 1998). Mortimer and Scott's framework consists of five aspects that are classified as *focus, approach* and *action* with respect to teaching as seen in Table 2. As previously mentioned, the sociocultural perspective was used in this study; hence, it was reasonable to utilize data-based and theory-based sociocultural framework for the purpose of this study. The framework can be the best option to explore the classroom discourse (Soysal, 2017).

Table 2. The Analytical Framework of Classroom Discourse

Focus	1. Teaching Purpose	2. Content
Approach	3. Communicative Approach	
Action	4. Patterns of the discourse	5. Teacher Interventions

Note. Reprinted from *Meaning Making in Secondary Science Classroom* (p. 25) by Mortimer, E., and Scott, P., 2003, UK: McGraw-Hill Education.

1. *Teaching Purpose*: The first aspect of the framework addresses the question regarding what to purpose of this part of the lesson with respect to science teaching is.
2. *Content:* The second aspect of the framework focuses on the nature of knowledge that is discussed between teacher and students through the part of the lesson.
3. *Communicative Approach:* As the central to the framework, communicative approach concerns the ways that teachers work with students in order to deal with students' ideas during the classroom discourse.
4. *Pattern of the discourse*: This aspect of the framework centers on the pattern of discourse between students and teachers in the classroom talk.
5. *Teacher intervention:* Teacher intervention can be called as a teacher discursive move. This aspect of the framework addresses the question as regards how teachers act for meaning making in the classroom discourse.

In this study, the aspects of the communicative approach and teacher intervention were adopted from Mortimer and Scott's (2003) framework in order to examine the relationship between teacher discursive moves and students' reasoning quality in different levels of ABI implementation. Moreover, the fluctuation among communicative approach enacted by teacher was examined in different levels of ABI implementation.

The aspects of communicative approach may be utilized to determine whether points of view are considered as well whether interaction between students and teacher occurs or not (Mortimer & Scott, 2003). In order to delineate the classroom talk, Mortimer and Scott (2003) describe four essential types of communicative approach on two dimensions; *dialogic/authoritative and interactive/non-interactive* as seen in Table 3.

Table 3. The Types of Communicative Approach

	Interactive	Non-Interactive
Dialogic	Interactive / Dialogic	Non-interactive / Dialogic
Authoritative	Interactive/ Authoritative	Non-interactive/ Authoritative

Note. Reprinted from "*Meaning Making in Secondary Science Classroom",* by Mortimer, E., and Scott, P., 2003, p. 25, UK: McGraw-Hill Education.

The use of the term "dialogic" is different from Bakhtin's perspective. According to Bakhtin, all of the discourses have to be dialogic, consisting of a non-interactive/authoritative approach (Mortimer & Scott, 2013). Mortimer and Scott agree with Bakhtin's ideas suggesting that "we have chosen to use the word 'authoritative' (while acknowledging the underlying dialogic nature of the interaction). Additionally, we have chosen the word 'dialogic' to contrast with an authoritative communicative approach so that we can draw upon the dialogic meaning of recognizing others' points of view. Thus, according to our definition, we are clear that in dialogic discourse the teacher attempts to take into account a range of students', and others', ideas." (p. 122). In dialogic discourse, teachers are open to various points of view. In other words, exchanges of ideas between student and teacher are not essential in the dialogic discourse. For example, the classroom discourse can be dialogic when teachers voice dominates the classroom discourse. Similarly, the classroom discourse can be authoritative when interaction between teacher and students occurs. Scott et al. (2006) compare the authoritative and dialogic discourse with respect to *basic definition, typical features, teachers' role, teachers' intervention and demands on students* in the science classroom. As seen in Table 4, teachers' discursive moves are differentiated in the discourses

Table 4. Key Features of Authoritative and Dialogic Discourse

	Authoritative Discourse	Dialogic Discourse
Basic definition	• focusing on a single perspective, normally the school science view	• open to different points of view
Typical features	• direction prescribed in advance • clear content boundaries • no interanimation of ideas • more than one point of view may be represented but only one is focused on	• direction changes as ideas are introduced and explored • no content boundaries • variable (low-high) interanimation of ideas • more than one point of view is represented and considered
Teacher's role	• authority of teacher is clear • teacher prescribes direction of discourse • teacher acts as a gatekeeper to points of view	• teacher assumes a neutral position, avoiding evaluative comments • greater symmetry in teacher–student interactions
Teacher's interventions	• ignores/rejects student ideas • reshapes student ideas • asks instructional questions • checks and corrects • constrains direction of discourse, to avoid dispersion	• prompts student contributions • seeks clarification and further elaboration • asks genuine questions • probes student understandings • compares and contrasts different perspectives • encourages initiation of ideas by students
Demands on students	• to follow directions and cues from the teacher • to perform the school science language following the teacher's lead • to accept the school science point of view	• to present personal points of view • to listen to others (students and teacher) • to make sense of others' ideas • to build on and apply new ideas through talking with others

Note. Reprinted from "The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning making interactions in high school science lessons," by Scott, P.H., Mortimer, E.F., & Aguiar, O.G. 2006, *Science Education, 90*(7), p. 628.

The term "dialogic" has been linked with the various ranges of classroom talk (Lehesvuori, 2013). According to Alexander (2004), dialogic inquiry includes promoting students' reasoning and conceptual understanding of science. He defines the essential elements of dialogic approach: *collective, reciprocal, supportive, cumulative and purposeful.* Lehesvuori (2013) argues that according to the Alexander, dialogic teaching can be integrated in all parts of the teaching process. However, the dialogical approach is seen as a type of the communicative approach that can be chosen with respect to the purpose of the instruction (Mortimer & Scott, 2003).

Mortimer and Scott's framework implies that the quality of teaching relies on a strategic use of any kind of communicative approach at the different parts of the lesson rather than the fact that any type of communicative approach is inherently better (Mercer et al., 2009). The type of communication approach used in science teaching depends on the purpose and the content of the lesson (Mortimer & Scott, 2003). Moreover, Scott et al. (2005) have highlighted that there must be a tension between authoritative and dialogic discourse to support meaningful learning in science classrooms. In other words, it is also stated that one type of discourse initiates the other one during meaning making in science classroom. For example, a teacher might conduct a scientific explanation about climate change in order to help students to discuss about the reasons for climate change. (Pimentel & McNeill, 2013). That is, teachers perform authoritative discourse when they have to use a social language of school science. In their study, it is also suggested that authoritative discourse provides support for classroom talk if it does not dominate the classroom discourse. The changes of the communicative approach in classroom talk refer to the rhythm of the discourse (Mortimer & Scott, 2003). In ABI teaching, teachers use both authoritative and dialogic discourse to support meaningful learning in science education.

There were many studies that examined the pattern of discourse in the science classroom. In the educational literature, it is commonly accepted that IRE sequence often leads to the authoritative approach, whereas IRFRF sequences are related to the dialogic approach (van Booven, 2015). In the dialogic sequence, different views are explored involving students in extended sequence of talk rather than evaluating students' responses as in the authoritative sequence (Mortimer & Scott, 2003). To put it differently, while there is more than one view in the dialogic sequences, only one point of view is given attention in the authoritative sequences. Similarly, authoritative oriented questions seek predetermined answers, however dialogic oriented questions tend to elaborate different points of views (van Booven, 2015). In science education literature, there are many attempts to identify whether triadic patterns promote or go counter to the aims of the inquiry-based approach (Aguiar, Mortimer, & Scott, 2010; Chin, 2006, 2007; Nassaji & Wells, 2000; Scott, Mortimer, & Aguiar, 2006; Tan & Wong, 2012; van Zee & Minstrell, 1997a).

Some researchers in the field of classroom discourse have a tendency to underline the important role of dialogic question sequences on supporting student-centered learning and teaching instead of authoritative question sequence (Chin, 2006, 2007; Roth, 1996; Russell, 1983; van Zee, Iwasyk, & Kurose, 2001; van Zee & Minstrell, 1997a, 1997b). On the other hand, others suggest (Aguiar et. al., 2010; Nassaji & Wells, 2000; Mortimer and Scott, 2013) that there must be a balance between performing authoritative and dialogic approach depending on the purpose of the lesson (As cited in van Booven, 2015, p. 1185). In other words, one of these approaches is not intrinsically good or bad in the classroom discourse. Tytler and Aranda (2015) state that "the effective orchestration of these moves involves a balance between the exercise of authority by the teacher to introduce and establish scientific knowledge at the same time as allowing room for students to explore the meaning of these often new and challenging ideas, in their own language and terms." (p. 428). In addition to these studies, the meaning and format of pattern of discourse are investigated by Soysal (2019). In his study of systematic review, Soysal (2009) concludes that although many researchers indicate that the format of the classroom discourse (triadic dialogue or open-ended sequence) is connected to the meaning of the classroom discourse (authoritative or dialogic), the aims of the discursive moves of teacher can change the expected results. For example, traditional triadic pattern may serve the dialogic discourse. In order to look at classroom discourse in detail, teachers discursive moves will be examined.

2.3.1. The Role of Teachers' Discursive Moves on Classroom Discourse

Based on Vygotsky's perspective on development and learning, learning occurs in the social context by means of language and other semiotic tools. In other words, learners rehearse the ideas among them primarily by way of talking on the social context (Mortimer and Scott, 2003). Therefore, classroom talk allows teachers to help students for making sense of scientific concepts. The concept of assistance of teachers through the *zone of proximal development* offers that teachers can lead classroom discourse on the social plane to promote student's conceptual understanding (Chin, 2006). This emphasizes the significance of classroom discourse between teacher and student, which can be seen as a type of scaffolding

(Bruner, 1986). Moreover, teacher discursive moves are described as communicative tools that provide meaning making of science concepts for students (Leach & Scott, 2002). Teacher discursive moves are important for giving students an opportunity to reason and to learn science (McNeill & Pimentel, 2010; Tytler & Aranda, 2015). Teachers' discursive moves might be wholly verbal (mimics, gestures, body posture, tone of voice) and nonverbal (verbalization) behaviors enacted by the teacher. This might lead us to think that the teachers' roles containing discursive moves or intervention enacted by them affect the classroom discourse. (Mortimer and Scott, 2003). Not only teacher questioning but also other comments and moves affect the classroom talk in science lessons (van Zee et al., 2001).

A group of researchers (e.g., Barnes and Told, 1977; Chin, 2007; Kim & Hand, 2015; Mortimer & Scott, 2003; Pimentel & McNeill, 2013; Tytler & Aranda, 2015) proposed some analyses of discursive moves performed by teachers to construct meaning through classroom talk. The common feature of these studies is to include fine-grained analysis of classroom talk within the sociocultural context. Moreover, the utterance of teachers is often assigned to the related categories like this study. For example, Tytler and Aranda (2015) developed a coding schema for expert teachers to guide classroom talk. They found that teachers discursive moves were categorized into three main categories: eliciting and acknowledging (e.g., acknowledging, marking, affirming), clarifying (e.g., requesting confirmation, re-voicing) and extending (e.g., requesting elaboration, challenging directly). Moreover, their coding schema of discursive moves overlapped with earlier coding schema developed by a great number of researchers (see, for example, Alexander, 2006; Scott, 1998). However, their coding schema of discursive moves was more extensive and particular in their description (Tytler and Aranda 2015). In this study, the code category of Soysal (2019) was used in order to investigate the fluctuation of teacher discursive moves enacted by teachers in the different levels of ABI implementation. Soysal (2017) developed a code catalogue of discursive moves by reviewing related literature. In the Soysal's (2017) code catalogue of TDMs, the discursive moves are located on continuum between authoritative and dialogic. Authoritative moves could be a logical exposition, a narrative, a selective summary, and foregrounding and backgrounding, transmitting knowledge, rejecting or accepting students' response against scientific knowledge. Dialogic moves could be prompting, extending, elaborating students' response, encouraging for justifying and challenging ideas, asking for comparing and contrasting various ideas, asking for clarification and tossing back. Authoritative moves of teachers limit students' contribution to the classroom talk while dialogic moves allow students to contribute to the classroom discourse. In the ABI approach, teachers are required to perform both authoritative and dialogic discursive moves (Soysal, 2017). Tytler and Aranda (2015) indicate the occurrence of rhythm of the discourse where both approaches are played out in inquiry-based teaching.

Based on Vygosky's sociocultural learning perspective, the quality of classroom discourse on the social plane is associated with the students' learning outcomes. Specifically, it is obvious that researchers examine the impact of teachers discursive moves on the interaction patterns of classroom talk (Chin, 2007), students' cognition (Aranda & Tyler, 2015; Chin, 2007; Hardy, Kloetzer, Moeller & Sodian, 2010; Kılıç, 2016; Martin & Hand, 2009; Soysal, 2017; van Booven, 2015), meaningful learning, students' perceptions toward scientific practices and knowledge (Moje, 1995; Zeidler & Lederman, 1989) as well as student's collaboration skills in a group (Gillies & Khan, 2009). The learning outcome is associated with the effectiveness of teaching. In the next chapter, the change of teacher discursive moves through their progress will be explained.

2.3.2. The Change of Teacher Discursive Moves Through Teachers Pedagogical Progression

In the ABI approach, the use of discursive moves affects the quality of classroom discourse. For example, TDMs can enhance the students' participation as well as the interaction between student-students and student-student interaction. Therefore, students' learning outcomes are enhanced. In this study, teacher discursive moves were explored with respect to the implementation level of ABI as one of the criteria of an effective classroom discourse. It is significant to comprehend the norms of classroom talk and to use a variety of discursive moves for a change in the classroom discourse (Polman & Pea, 2001; Tabak & Baumgartner, 2004). Researchers have explored the characteristics of classroom discourse patterns with respect to various aspects through different quality of teaching practices.

Researchers mainly examined the difference between various implementation levels regarding teacher questions (see, for example, Benus et al., 2013; Cikmaz, 2014; Gunel, Kingir & Geban, 2012; Kılıç, 2016; Martin & Hand, 2009). Erdogan and Campbell (2008) examined the differences between the types and numbers of teachers' questioning in the low level of constructivist teaching practices (LLCTP) and high level of constructivist teaching practices (HLCTP). The level of teaching practice corresponded to the quality of teaching practices. The type of teacher questioning was analyzed as regards three categories that were open-ended, close-ended, and task-oriented questions. They found a significant difference in the total number of questions posed by teachers. Furthermore, teachers in the high level utilized significantly more open and close-ended questions than teachers in the low-level. Therefore, they associated the total number of questions with effective constructivist teaching practice. On the other hand, Martin and Hand (2009) state that the total number of close-ended questions should be decreased to change the focus of the lesson from authoritative discourse to dialogic discourse. Gunel et al. (2012) examined the quality of teacher questioning in different levels of ABI implementation. It was found that teachers in high level asked questions that helped students talk while teachers in low level evaluated student responses as "yes" or "no". Moreover, it was stated that increased level of teachers' questions was related to the negotiation happening in the classroom.

Benus (2011) investigated the patterns of dialogues that were performed by an experienced teacher through argument-based inquiry implementation and how the teacher promoted the agreeability of ideas in the pattern of dialogue. It was found that the experienced teachers conducted three types of whole-class dialogue; teacher talking to (TT) students, teacher talking with (TW) students and teacher thinking through (TH) ideas with students. These types of dialogues were based on previous studies (Edwards & Mercer, 1987; Mercer, 1996; Mortimer & Scott, 2003). The study revealed that as time progressed, the teacher increasingly performed thinking through (TH) ideas with students in the patterns of the dialogue. In addition, students were more involved in dialogue as time progressed. The study also showed that the teacher encouraged students regularly to be involved in consensus-making activities. Meanwhile, students without the support by the teacher asked each other whether they agreed or disagreed with each other's ideas.

Kim and Hand (2014) conducted a study with six elementary teachers in order to investigate the argumentation discourse in different quality levels of argument-based inquiry teaching. The quality of teaching was determined using Reformed Based Observation Protocol (RTOP). The participants of the study included three teachers with high RTOP scores, one teacher with medium RTOP score and two teachers with low RTOP score. There was no difference in discourse patterns in teacher classroom with medium and low RTOP score; therefore, the teacher with low RTOP score was included in teachers with medium RTOP score. The researchers came up with four categories of classroom characteristics emerging from analysis of classroom videos; "*structure of teacher and student argumentation, directionality, movement and structure of student talk*". Firstly, the structure of teacher and student argumentation characteristic indicated that teachers and students in the class with the high RTOP score showed more challenging, supporting, rejecting, and defending than the teachers and students in the class with medium and low RTOP score with respect to argumentation. Secondly, the finding about directionality characteristic revealed that teachers with medium and low RTOP score tended to give explicit information more frequently than the teachers with high RTOP score. Thirdly, teachers with high level showed more tendency to circulate around the class during interacting with the students. Finally, the frequency of using evidence, defined as the structure of student talk, was higher in the high-level than low and medium level. Similarly, other studies indicated that the implementation level of ABI increased, students generated more evidence-based claims (Benus et al., 2013; Martin & Hand, 2007).

Alexander et al. (2017) conducted a project titled "*Classroom talk, social disadvantage and educational attainment: raising standards, closing the gap"* with Science, Mathematics and English teachers in order to enhance the quality of their classroom talk, in this way, they improved students' meaningful learning and their contribution to classroom talk. Teachers in the intervention group participated in a-20-week PD program that focused on a dialogic teaching developed by Alexander (2007). In this programme, intervention teachers worked on teacher talk moves which elaborated and expanded students' responses. Firstly, they realized that teachers in the intervention group asked more open-ended questions than in the control group. Secondly, intervention teachers enacted more discursive moves of re-voicing, rephrasing, promoting students to make evidence-based reasoning, challenging and asking for justification. Thirdly, students in the intervention teachers' class performed greater challenge, argumentation and analysis.

Overall, the implementation level of ABI has been investigated regarding different perspectives in this study. However, there is little evidence about how teachers move toward higher implementation level of ABI. In this study, the frequency of occurrence of TDMs was determined and compared in different implementation levels. Moreover, the quality of classroom discourse is directly associated with the students' learning outcomes (Nystrand et al., 1997). In the next chapter, this relationship will be described in a detailed way.

2.3.3. The Relationship Between Teacher Discursive Moves and Students' Cognitive Contribution

Cognitive contribution explains how students take advantage of classroom discourse pioneered by teacher discursive moves (Soysal & Yılmaz-Tuzun, 2019). Thus, the change in cognitive contribution means how students' gains increase or decrease in the learning environment guided by teacher discursive moves. In the literature, students' cognitive contribution was examined in the qualitative and quantitative ways. The quantitative contribution was investigated with respect to the number of questions that students asked (Cikmaz, 2014) and the proportion of student talk (Martin & Hand, 2009; Soysal & Yilmaz-Tuzun, 2019) in the studies. Moreover, the students' cognitive contribution was examined with respect to students' cognitive pathway (Grimberg & Hand, 2019; Kılıç, 2006), reasoning quality (Soysal & Yilmaz-Tuzun, 2019; Yılmaz, 2016) and argumentation structure (Martin & Hand, 2019) by using various frameworks.

Research has been conducted on the relationship between interaction patterns of classroom discourse and students' cognitive contributions. Traditional classroom discourse often includes triadic pattern of interaction (e.g. IRE) where the teacher asks questions, students respond, then the teacher evaluates students' response against canonical knowledge of science with little interactions among students (Macbeth, 2003; Mehan, 1979). In inquiry-based science classrooms, only traditional science discourse patterns do not occur since these patterns rely on teachers-oriented instruction and questions whom answer is known (Polman & Pea, 2001). The major difference between inquiry and non-inquiry classroom environment with respect to cognitive process is the teachers' discursive moves to student's responses. In the inquiry classroom, teacher questioning as a type of discursive moves aims to promote students to expand on their previous answers instead of evaluating the correctness of students' response (Roth 1996). In the IRE (initiate-response-evaluation) pattern, students' contribution is restricted as a short or one-word response (McNeill & Pimentel, 2010). Aranda and Tytler (2015) investigated the discursive moves of six expert teachers who conducted inquiry teaching in their classrooms. They have concluded that participant teachers enact various discursive moves that go beyond the traditional triadic pattern (IRE) where there is a limited opportunity for elaboration of students' responses. Moreover, these teachers prompted student's response in various ways; however, they seldom gave an evaluation to students' response. Aranda and Tytler (2015) maintain that these discursive moves enable students to advance thinking instead of directing scientific explanation in a way unrelated to the students' response and thinking. Also, Driver et. al. (2000) conclude that teachers might have inadequate skills requiring shifting from traditional triadic pattern (IRE) to more dialogic pattern of interaction although this approach is suggested by the national curriculum (Alozie, Moje & Krajcik, 2010). Mercer and Littleton (2007) have proposed strategies in order to go beyond the IRE interaction pattern, for example, prompting students' responses, asking open-ended questions, giving other students an opportunity to respond before evaluating student's response. Finally, the third move of the triadic pattern is associated with the students' cognitive contribution to the classroom discourse. On the other hand, Mortimer and Scott (2003) argue that the classroom discourse should include both types of interaction patterns depending on the aims of the lesson.

Chin (2006), on the other hand, concludes from his study that when teachers perform discursive moves that elaborate students' answers as a third move rather than evaluating student's response, students will reach high order thinking skills (e.g, hypothesizing, deducing). Similar to Chin's (2006) findings, van Booven (2015) has found that "the fixed nature of authoritative-centered questioning can dramatically limit students' opportunities to demonstrate higher order scientific understanding, while dialogic-centered questions, by contrast, often grant students the discursive space to demonstrate a greater breadth and depth of both canonical and self-generated knowledge." (p. 1198). In addition, van Zee and Minstrell (1997a) offer "a reflective toss" as a feedback moves of IRE sequence. These discursive moves give students responsibility of thinking. van Zee and Minstrell (1997b) also propose the contribution of "reflective toss" as follows: 1) make their meanings clear, 2) consider a variety of views, 3) monitor the discussion and their own thinking. While recent research has shown that authoritative discursive moves limit students' contribution, dialogic discursive moves support students students' contribution.

Some studies have indicated that there is a positive relationship the structure of teacher questioning (open-ended and closed-ended question) and students' cognitive contribution, which refers to the quality of student talk (Martin & Hand, 2009; McNeill & Pimentel, 2010). Open ended questions such as asking for inference, justification, and judgement (Blosser, 1973) enable students to explain their own ideas and thoughts. McNeill and Pimentel (2010) have concluded that open-ended questions promoted students to be involved in argumentation with respect to offering evidence and evidence for their knowledge claims as well as allowing dialogic interaction among students. Similarly, Martin and Hand (2009) have examined the factors that teacher's effort to change their own pedagogical practices in order to carry out Argument-Based Inquiry approach. They have reached a conclusion that as teachers change their practices from teacher-centered teaching to student-centered teaching, teachers will ask more open-ended questions instead of close-ended question. In their study, this change in the teacher questioning has helped to increase student voice. Student voice is determined by looking into the proportions of the lesson time which belongs to students. Increasing student voice allows them to use elements of argumentation such as making evidence-based claims and refuting others claim. On the other hand, Boyd and Rubin (2006) argue that the contingent questions increase the student's contributions rather than the open-ended questions. This means that an open-ended question that do not rely on students' previous utterance may not expand student talk.

Soysal and Yılmaz-Tuzun (2019) have investigated the relationship between teacher discursive moves and students' cognitive contribution with respect to reasoning quality and the structure of observed learning outcomes (SOLO) in quantitative and qualitative manner. The researchers have developed the code catalogue of TDMs considering the related literature which includes eight main categories and twenty-one subcategories. They have found that all dialogic discursive moves do not increase the qualitative contribution of students. Communicating discursive moves such as probing, clarifying and elaborating as well as monitoring discursive moves might increase students' voice in the classroom discourse, but not the quality of student talk. Moreover, evaluation-judging-challenging discursive moves not only increase student voice but also the quality of classroom talk.

In addition to teachers' discursive moves, teachers' beliefs are important for framing teachers' moves (Nespor, 1987; Torff & Warburton, 2005). Pimentel and McNeill (2013) investigated five secondary science teachers' approach during classroom dialogue and their beliefs related to the science talk. The participant teachers were involved in PD program that emphasized strategies and approaches to increase students' classroom discussion. The data were collected through interviews and video recordings of lessons. They found that students made limited contributions to discussion like a short sentence response that did not involve reasoning. In addition to students' contributions, it was found that teachers rarely asked probing questions and request students to comment on a student's response. Their study highlighted why teachers adopted an authoritative approach during classroom talk although they believed student-centered discussion as the ideal. Teachers suggested the reasons for the limited students' contributions as follows: inadequate prior knowledge of students, time pressure and feeling incapable of involving students in discussion effectively. That is why, the PD program is needed to support the classroom discourse for the students' meaning making process.

2.3.4. Need for Change in Teachers' Discursive Moves through the Professional Development Programme

Current research as well as national and international reform movements indicate that discourse should be a more important component of conceptual learning in classroom settings (Alexander, 2005). On the other hand, however, teachers mostly have difficulty in engaging students in classroom discourse (McNeill & Krajcik, 2008). Therefore, teachers should be supported for improving their classroom discourse by means of PD programs (Benus et al., 2013; Kazemi & Hubbard 2008; Pimentel & McNeill 2013). The components of PD program have an important role to meet the requirements for changing their discursive practices in their classroom (Zaccarelli et al., 2018). Unfortunately, Sparks and Hirsh (2007) indicate that many teachers are not involved in an effective PD program. In Turkey, PD programs often include "one-shot session, sit-and get and one size fits all approaches" (Budde, 2011, p. 21) without an ongoing support. In the review of related literature, Desimone (2009) states that there are five significant components of PD program. Current studies consist of these main components as essential aspects of PD programs (Desimone, 2009). These components are as follows; 1) *content focus:* that offers teachers pedagogical and content knowledge in PD program 2) *active learning*: opportunities for teachers to be involved in negotiation among themselves and to examine student work rather than listening to the trainer 3) *coherence* that focus on teachers' beliefs, pedagogical content knowledge and background of their school 4) adequate *duration* with respect to time spent in the programme and regular meetings 5) *collective participation:* opportunities that enable interaction among themselves. In this study, participant teachers have implemented ABI in their classroom within the context of PD program that meets these criteria. NRC (1996; 2000) underlines a key role of PD program in developing teachers' understanding and implementation skills of inquiry-based approach.

Similar to Desimone (2009), the ongoing support should facilitate teachers to integrate what they have learned from the PD program into their classroom (Darling-Hammond, 2000). Darling-Hammond et al. (2009) state that the duration of PD program is directly related with the student and teacher learning outcomes. It is apparent that effective PD programs have to be considered as a process rather than an event (Loucks-Horsley et al., 1987, 1998). Martin and Hand (2009) have stated that the change of teacher practice will last at least 18 months. Moreover, the progression of teacher pedagogy can be viewed as a continuous and an ongoing effort (McLaughlin & Marsh, 1978). In the literature, teacher's pedagogical change is investigated in the short-term PD program (Benus et al., 2013). In this respect, in the literature, it is needed to explore teachers' pedagogical improvement in a longitudinal and sustained PD program.

2.4. Summary of Literature Review

In this chapter, existing related literature and theoretical frameworks of this study are presented. Argumentation is described as an individual and a social process. In the literature review, the reasons for choosing immersion approach among the three argument-based approaches have been discussed with respect to the needs of the study. As one of the immersion approaches, ABI approach can be implemented in a different quality. Moreover, the implementation quality of ABI approach as one criterion of quality of classroom discourse is directly associated with the students' cognitive contributions. The framework of classroom discourse has been explained as regards Vygotsky's sociocultural learning and teaching perspective. Thus, classroom discourse as a factor of determining quality of ABI has been deeply analyzed through in-depth and fine-grained sense. Research on the ABI provides little insight about how the classroom discourse change as their pedagogical progression toward ABI. Moreover, recent research shows that there is little evidence about the relationship between the teacher discursive moves students' and reasoning quality.

CHAPTER 3

METHOD

This chapter will present the methodology of this study that aims to investigate the classroom discourse with respect to teachers' discursive moves, communicative approaches and students' reasoning quality in teachers' medium and high level of ABI implementation. First, the research design of this study will be addressed. Afterwards, the context of the study, data collection and analysis, trustworthiness of the study as well as the limitation of the study will be respectively discussed in detail. Following research questions are investigated in this study.

1. What are the discursive moves (TDMs) performed by teachers in the medium and high levels of ABI implementation?
2. What are the communicative approaches performed by teachers in the medium and high levels of ABI implementation?
3. What is the relationship between teachers' discursive moves and students' reasoning quality in medium and high levels of ABI implementation with different science contents?

3.1. Research Design of the Study

In this study, qualitative research approach was used in order to address the research questions. Qualitative inquiry is to find out what people do and tell or to "get grasp, hear, catch and comprehend" what something means (Grant, 2008, p. 1). In the qualitative research, data are collected from participants in their natural settings or in a place (Creswell, 2007; Stake, 1995). In this context, data were collected from teachers' classrooms by means of video-recording in order to investigate the differences between classroom discourse in medium and high levels of ABI implementations.

As a qualitative research approach, a case study research design was utilized to answer each research question in this study because it allowed the researcher to understand the classroom discourse in two teachers' medium and high levels of ABI implementations. According to Sanders (1981), "case studies help us to understand processes of events, projects, and programs and to discover context characteristics that will shed light on an issue or object" (p. 44). Similarly, a case study is proposed if the problem to be focused "relates to developing an in-depth understanding of a 'case' or bounded system" (Creswell, 2007) , and if the purpose is to understand "an event, activity, process, or one or more individuals" (p. 496). For this study, the cases were two elementary science teachers. The types of case studies are categorized as *intrinsic, instrumental,* or *collective (multiple)* regarding the aim of the study (Stake, 1995). While an intrinsic study focusses on a specific individual, group of individuals to understand the phenomenon, a multiple case study is used when more than a single case is included in the study. A researcher is involved in an instrumental study in order to deeper understand a theoretical problem rather than only further than only a specific case. In this study, multiple cases have been selected purposefully in order to represent various perspectives on the problem (Creswell & Poth, 2018). The multiple case study provides researchers with identifying differences or similarities within as well as across the cases (Yin, 2003). Therefore, findings are replicated across the case. In this study, classroom discourse in different levels of ABI implementation was identified within individual (Teacher A and B) cases. Then, cross-case analysis was carried out to explore the differences and similarities among the results of both cases. The reason for conducting cross case analysis was to investigate differences and similarities among classroom discourse and student' reasoning in teachers' medium and high level of ABI implementation although the contents of ABI implementation and students' grade levels were different for each case.

3.1.1. The Participants

For the present study, the participants were two elementary science teachers who agreed to participate this study voluntarily, and their students in their classrooms where teachers implemented ABI approach. Within the scope of the project, ethical permission was obtained before starting the project. Moreover, signed consent forms were taken from teachers and students regarding their approval for data collection with video-recording during the classroom implementations. In order to ensure the confidentiality of the participants' identity, these two teachers were referred to as Teacher A and Teacher B in this study. Purposeful sampling was used to make selection among the teachers who have attended PD program within the scope of the project. In this study, the criteria for purposefully selecting the teachers were the level of teachers' ABI implementations. Hence, the researcher mainly focused on the differences between classroom discourse in the teachers' medium and high levels of ABI implementations.

The participant teachers were voluntarily involved in a 3-year longitudinal PD program (5 academic semesters) conducted within the scope of the project funded by The Scientific and Technological Research Council of Turkey (TUBITAK), Project No, 109K539. For the selection of participant teachers, the data of State Planning Organization whose current name was the Ministry of Development were used regarding the provinces' development level. In the study of the *Socio-Economic Development Ranking Survey of Provinces and Regions published by State Planning Organization* in 2003, provinces were evaluated with respect to social and economic parameters; thus, they were classified with respect to the level of development. In this project, there were 15 participant teachers from provinces with 5 different development level. The development level of provinces of teachers in this study will be given below.

The main aim of this project was to help students learn science concepts and increase their scientific literacy by using ABI approach. In addition, it aimed to change teachers' learning perceptions, pedagogical practices and epistemological beliefs towards student-centered approach where scientific thinking was dominant in classrooms. Therefore, the PD program was conducted to increase the participants teachers' pedagogical understanding and implementation skills of ABI teaching in middle school science classroom, in turn, increase students' reasoning skills and motivation towards science. To this end, the content and structure of PD program was built on data-driven evidence, practice-based understanding and expectation of educational reform. The content and structure of PD program will be further explained in detail.

The PD program consisted of three major parts as following: in-service trainings, on-going support and measurement and assessment activities as given in Table 5. Within the scope of the project, a total of five in-service trainings were conducted during the 3-year project. Participant teachers attended a five-day-in-service training at the beginning of each semester. Each in-service teacher training focused on specific themes that were important for ABI approach. The themes of each in-service teacher training were as follows; introduction of argument-based inquiry teaching, the importance of questioning, the evaluation of ABI classroom implementation, the change in teachers' pedagogical practice and sharing of classroom experience and teacher negotiation cycle. Although each training had a particular theme, there were three key components of training program. First, each training enabled teachers to question their beliefs and perceptions towards learning and teaching. Second, the in-service teacher trainings gave an opportunity to the participant teacher to experience an argument-based inquiry as learners. This activity which teachers experienced as a learner not only lightened the value and joy of ABI learning but also allowed teachers to be aware of and reflect on their own learning process. Third, the teachers were engaged in curriculum preparation activities to implement the inquiry-based teaching in their own classrooms in the following academic year. In these activities, they constructed concept maps, identified big ideas of a unit, generated a series of inquiry activities, and discussed about the evaluation tools as well as potential obstacles to be faced during the classroom implementations. Within the PD program, ongoing supports (online and on-site support) were given to the participant teachers of the project. Through ongoing support, teachers were allowed to improve their ABI implementation in their classroom by giving feedback on teachers' classroom implementation. Finally, teachers were allowed to improve their ABI implementation in their classroom by giving feedback on teachers' classroom implementation.

Table 5. The Part and Content of the PD Program

The Parts of PD program		The Aim
In-service Teacher Trainings	Pedagogical discussion about teaching and learning	To enable teachers to make reflection on their belief and practices about teaching and learning
	Experience of ABI implementations as a learner	To enable teachers to experience ABI implementation as a learner
	Curriculum Preparation Activities	To enable teachers to make preparation of ABI implementation with their colleague.
On-site Support		To support teachers to increase the effectiveness of their ABI implementations in their classroom
Measurement and Assessment Activities		To give feedback teachers on their classroom practices.

3.1.1.1. Teacher A and the Students

Teacher A was 30 years old. She taught science to 6th, 7th, and 8th grade students for two years in a public school. At the beginning of the project, teachers were suggested to implement ABI in the 6^{th} or 7^{th} grade level in order to follow student' outcomes at least two years due to the purpose of the project mentioned before. However, this did not seem possible for all teachers because of their school dynamics and schedules. In other words, according to the number of science teachers in their school and academic program, teachers entered one or more than one grade levels in that an academic year. Teacher A taught science to the only 6th grade students in the second year of the project during which data were collected. The school of Teacher A was in the Kayseri province which was at the 2^{nd} level of development according to the study of *the Socio-Economic Development Ranking Survey of Provinces and Regions* published by the State Planning Organization. Teacher A's information related to the ABI implementation is given in Table 6. Moreover, the content of the ABI Implementations of Teacher A is given in Table 7.

3.1.1.2. Teacher B and the Students

Teacher B was 40 years old. She taught science to 6th, 7th, and 8th grade students for seventeen years in a public school. The school of Teacher B was in the Siirt province which was at the 5^{th} development level. Teacher A taught science to only the 8th grade students in the second year of the project when data were collected. Teachers B's information related to the ABI implementations is given in Table 6. Moreover, the content of the ABI Implementations of Teacher B is given in Table 7.

Table 6. Information Related to the ABI Implementations of Teachers

Teacher	Implementation Level	Grade Level	Topic of the Lesson	Total duration of lesson (min)	Duration of Whole-Class Discussion (min)	Number of Students Girls	Boys
	Medium	6th	Force and Motion	80	57	13	15
	High	6th	Light and Sound .	120	65	13	15
B	Medium	8th	Reproduction, Growth and Development	120	58	14	21
	High	8th	Electricity in Our Lives	120	57	14	21
			TOTALS	440	237	27	36

As seen in Table 6, Teacher A and Teacher B implemented ABI in different science topics at different grade levels. The total number of students in Teacher B's class was more than in Teacher A's class. The number of girl and boy students in Teacher A's class was close to each other, while the number of boy students in Teacher B's class was higher. The duration of the lessons was the same except "Reproduction, Growth and Development" implementation since students only conducted a discussion in a small group rather than carrying out their experiment like other implementations. The whole group discussion was analyzed in this study since there was not any recording of the small group discussions.

3.2. The Context of the Study

3.2.1. Implementation of Argument-Based Inquiry

In this study, the implementation of ABI consisted of three phases as follows; 1) initial discussion, 2) scientific investigation of student, 3) whole-class discussion. In the initial discussion, the teachers conducted discussion about the science topic (for example; factors that affect brightness of the bulb) in order to reveal the prior knowledge of students. This negotiation gave an opportunity to students to realize to what extent they had knowledge about the topic. The purpose of the initial negotiation was that students had a potential to form their research questions. In the scientific investigation of the students, they were allowed to ask their questions that they wondered to investigate as a group through negotiation with each other. In the meantime, teachers supported small group discussions by posing questions such as "do you agree with your friend about this? why do you want to investigate this question?". These types of questions allowed the students to reflect on their thinking and to trigger the negotiation among small groups. Later, students were requested to conduct their investigation with given materials in order to address their questions. At the end of their scientific investigation, they were asked to make their claim based on the evidence. During the second phase, the students wrote the process and findings of their scientific investigation on the investigation/lab manual. In the whole-class discussion, they presented their work by using argument structure that was question-claim-evidence to the whole class. After each group presentation, whole class discussion was carried out, which enabled the students to negotiate their claims with each other. At the end of the whole group discussion, the students were asked to fill in the discussion part of their investigation/lab manual individually.

3.2.2. Science Content of ABI Implementation

Participant teachers conducted ABI implementation in different science contents as seen in Table 7. In this study, the relationship between teacher discursive moves and students' reasoning quality was also examined in different science contents considering the students understanding of science concepts as well as detecting their misconceptions.

Table 7. The Content of the ABI Implementations of Teachers

	Curricular unit	Content	Characterizing concepts	Description
Teacher A	Force and Motion	Buoyancy	Buoyancy, dynamometer, mass, volume, gravity, gravity force, floating, sinking	Students negotiated the factors that affect buoyancy such as, the type of liquids, types of substance by conducting their investigation.
	Light and Sound .	Sound	Sound, vibration, sound wave, molecules, sound frequency, propagation of sound	Students were given an opportunity to investigate the factor that affects propagation of sound as well as sounds' thickness through negotiation within small and whole group.
Teacher B	Reproduction, Growth and Development	Reproduction, Growth and Development in Human	Sperm cell, egg cell, sperm tail, fertilization, zygote, embryo, cell division	Students were involved in negotiation about the relationship between sperm cell, egg cell, embryo and baby
	Electricity in Our Lives	Conductivity	Electric, resistance, insulator, conductive, ohm,	Students negotiated the factors that affected the electric conductivity of substance, such as; the type, length and thickness of the wire while engaging in their investigation.

3.2.3. The Criteria for Teachers' Level of ABI Implementation

Within the framework of the project in which teachers were involved, their implementation level of ABI was determined by Reformed Teaching Observation Protocol (RTOP) (Sawada et al., 2002) that was an instrument to measure "reform practices in math and science" (p.245). Original RTOP developed by Piburn and his colleagues (2000) is designed to evaluate "the reformed" teaching implied by NCTM (1989, 1991, 1995, and 2000) and the National Science Education Standards (NRC, 1995) and to enable a score to the extent which reform-based teaching practices are implemented. Then, Martin and Hand (2009) modified the instrument in order to undertake the alignment between components of argument-based inquiry mentioned in the chapter of literature review and original RTOP's items. Researchers found that 13 items of RTOP, which were related to the argument-based inquiry teaching practice, were classified into four categories: *student voice (5 items), teacher role (2 items), problem solving and reasoning (5 items), and questioning (1 items*) (Martin & Hand, 2009). The modified RTOP is used to determine the teachers' level of ABI implementation. The description of the categories is as follows: 1) *Student voice***:** allowing students to share their ideas 2) *Teacher role:* giving students an opportunity to take on responsibility of their own thinking, problem solving process 3) *Problem solving and reasoning:* promoting students to find out their problem-solving method instead of explaining method and asking reasons for their solution method. 4) *Questioning:* asking open-ended questions to students (Akkus, 2007). Previous research showed that teachers levels of ABI teaching were associated with the teachers RTOP's score (Cavagnetto et al., 2010; Martin & Hand, 2009). In the scope of the project, three items were added to the RTOP category of questioning since one item was not enough to measure teacher questioning as provided in Table 8. When looking into categories and items, the overall items of RTOP reflect enacted teachers' discursive moves and communicative approaches. However, in this study, fine-grained analysis of teachers' discursive moves was conducted.

Table 8. RTOP Categories

Student Voice	- The instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein. - The focus and direction of the lesson was often determined by ideas originating with students. - Students were involved in the communication of their ideas to others using a variety of means and media. - There was a high proportion of student talk and a significant amount of it occurred between and among students. - Student questions and comments often determined the focus and direction of classroom discourse.
Teacher Role	- The teacher acted as a resource person, working to support and enhance student investigations. - The metaphor "teacher as listener" was very characteristic of this classroom.
Problem solving and reasoning	- This lesson encouraged students to seek and value alternative modes of investigation or of problem solving. -Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures. - Students were reflective about their learning. - Intellectual rigor, constructive criticism, and the challenging of ideas were valued. - Active participation of students was encouraged and valued. - Students were encouraged to generate conjectures, alternative solution strategies, and/or different ways of interpreting evidence.
Questioning	- The teacher's questions triggered divergent modes of thinking. - Questioning to encourage student's investigation - Teacher's questioning to promote students' negotiation and multi- person conversation - Opportunity for learners to pose their own questions

Note. Reprinted from "Changes in A Science Teacher's Pedagogical Practices and Beliefs Following ABI: Onsite Ongoing Professional Support", by Erdal, F. 2018, p. 60, Unpublished master's thesis. METU, Ankara, Turkey.

Each item of observation protocol is scored zero to four-point. While the meaning of zero point is that the related teaching practices have never happened in the classroom, the meaning of four point is that related teaching practices have been very descriptive of the classroom. Within the scope of the project, teachers' implementation levels of ABI teaching were categorized with respect to the score of RTOP based on related research (Akkus & Hand, 2011; Martin & Hand, 2009). In this study, the overall RTOP scoring between 2 and 3 equaled to medium level of ABI implementation while the overall RTOP scoring between 3 and 4 equaled to high level of ABI implementation.

3.3. Data Collection

The data source of this study was classroom videos of two science teachers involved in a 3-year longitudinal PD program. As mentioned in the context of this study, during the PD program, the teachers participated in training at the beginning of each semester and conducted the ABI implementation in their science classrooms. Classroom videos were recorded by means of a video-camera. Teachers were requested to record their ABI implementation through video-recorder in order to evaluate their ABI implementation by the researchers of the project. Moreover, it was reminded that a video recorder had to be located at a convenient place in the classroom to capture all the students' voices and images. Teachers were also proposed to record group discussion during the ABI implementation while they were walking between the groups. The recording of the whole classroom discussion was used as data source because all group discussions were not recorded with any recorders. The duration of the whole class discussion and content of each implementation is given in Table 6. All of the classroom videos were transcribed verbatim to analyze classroom discourse with respect to TDMs, communicative approaches enacted by teachers and students' reasoning qualities.

3.4. Data Analysis

In order to investigate classroom discourse in the teachers' medium and high levels of ABI implementations, transcribed data were analyzed by means of the systematic observation, a branch of the discourse analysis (Mercer, 2010). Systematic observation fundamentally includes assigning observed interaction to previously certain categories and it is adopted to reach quantitative description. Therefore, numerical comparison can be done across and within data sample (Mercer, 2010). In this study, systematic observation contributed considerably to understanding of classroom discourse within and across the cases in this study (Coll & Edwards, 1997). The analysis of transcribed classroom videos was carried out in three steps as follows; forming episodes, coding and counting. The systematic observation consists of coding and counting (Mercer, 2010). Firstly, transcriptions of classroom videos were broken into the episodes based upon discussion of the topic during the ABI implementation This means that the change of topic points out a different episode. The student and teacher utterances were taken into account while determining different episodes. In the example given below, while the appearances of sperm and eggs were discussed, the teacher's bold utterance initiated to discuss new topic. Therefore, the bold teacher utterance was the sign for the new episode. Moreover, the individual (teacher or student) who initiated the episode varied across the implementations.

T: What does egg look like?

A: Egg looks like a circle.

T: What does sperm look like?

S: Sperm looks like a snake.

S: I agree with my friends.

T: **Well kids, I'm curious about something now. Why now they may be different? What would be the reason?**

S: One of them is male and the other is female.

The number of talks of turn and the episodes are given for each implementation of both teachers in Table 9.

Table 9. The Number of Talks of Turn and the Episode for Each Implementation of Teachers

	Teacher A		Teacher B	
	Medium Level Implementation	High Level Implementation	Medium Level Implementation	High Level Implementation
The number of talk of turn	459	413	557	575
The number of the episode was initiated by the teacher	17	12	21	16

Secondly, teacher and student utterances were assigned to the codes in the code catalogues. In this study, the researcher trained herself with the help of external coders during the coding processes through regular discussion meetings. Three types of coding were conducted to address the research questions. In the systematic observation, the code catalogues are either developed by the researchers or off-the-shelf system is used by them (Mercer, 2010). The code catalogues developed by other researchers were used. Teacher utterances were coded using the coding catalogues of teacher discursive moves (TDMs) (Soysal, 2019). In order to investigate the relationship between student' reasoning quality and TDMs, student utterances were coded using coding categories of students' reasoning quality (Furtak et al., 2010). Moreover, the episodes of the lesson that consisted of teacher and student utterances were analyzed using the types of communicative approach (Mortimer & Scott, 2003). After the coding processes, the number of coding of teacher and student utterances was counted so as to reveal the percentages and frequencies of occurrence of types of discursive moves, communicative approaches enacted by teachers as well as the typology of students' reasoning.

Systematic observation has also inherent limitations which are "ambiguity of meanings, the temporal development of meanings, and the fact that utterances with the same surface form can have quite different functions." (Mercer, 2010, p. 4). Moreover, in systematic observation the classroom discourse is assigned to the specific categories of moves since classroom talk is regarded as a continuing and dynamic process. In order to overcome the limitations of systematic observation, contextual issues were considered through analyzing the classroom videos in this study.

3.4.1. Code Catalogue of Teacher Discursive Moves (TDMs)

Teacher discursive moves were analyzed in order to answer the first research question of this study. Soysal's (2019) code catalogue of TDMs was utilized. This catalogue consists of 10-category, 34 sub-category and more than 200 analytic codes that show the types and functions of discursive moves as seen in Table 10. These analytic codes were also used in the study of Soysal and Yilmaz-Tuzun's (2019) and Soysal's (2017, 2018). It is argued that a wide variety of teacher discursive moves was analyzed by using code categories of TDMs. The catalogues of other studies were developed based on theory-based and data-driven. In other words, when developing code catalogues, not only existing literature but also emerging data were considered by Soysal (2017, 2018) and Soysal and Yilmaz-Tuzun (2019). In this study, study-specific TDMs were emerged; that is, these discursive moves were not involved in Soysal's (2017; 2018 2019) and Soysal and Yilmaz-Tuzun's (2019) catalogues. Lincon and Guba (1985) state, when necessary, the catalogue should be redefined through adding codes based on a new study. In this sense, new codes were added to the catalogue of discursive moves when the new teacher discursive moves appeared in the data. The observed teacher discursive moves with the definition of the sub-categories as well as the examples will be given in the Appendix B.

Table 10. The Code Catalogue of TDMs

Higher-order categories	Sub-categories as TDMs	Sample Utterances
Knowledge Providing & Evaluating (KPE)	Presenting logical expositions	"Scientists refer the union of the sperm cell and the egg cell as zygote".
	Soft evaluation	"Two sperms can enter the egg at the same time"
	Affirmation-cum-direct-instruction	*
	Direct affirmation	*
	Rejecting	"It is not aluminum"
	Verbal cloze	"Then the weight and lifting force…."
Observe-Compare-Predict (OCP)	Asking for simple comparison	"Is there any difference between male and female voices?"
	Asking for making prediction	"If you carve a stone, will the stone sink or float in the water?"
	Asking for making observations	"Did the stone sink?"
Communicating (COM)	Probing	"Why do the eggs and sperms have different shapes?"
	Requesting for clarification	"You said that if nickel-chrome wire is connected to the end of the copper wire, the electric conduction is the middle of the two. What do you mean, the middle of the two?"
	Reformulating	"You're saying that the research question must be provable."
	Embodying	"For example, you have unpeeled lemon and peeled lemon."
Monitoring & Framing (MOF)	Enacting procedural/conceptual meta-discourse	*
	Focusing	"Your friends just said that "zygote occurs after the sperm has entered the egg"
	Monitoring (type-1: on-moment)	"I'm asking why we would forcibly sink a ball into the water."
	Monitoring (type-2: prospective)	"Don't forget about this, we'll talk about it later."
	Monitoring (type-3: retrospective)	"Your friend said something about a million sperms."
	Summarising (consolidating)	"You said that all liquids apply buoyancy to objects and the direction of buoyancy is opposite to the direction of the object's weight. But you said the amount of buoyancy can vary."
	Selecting	*
	Asking about mind-change	*
Evaluating-Judging-Critiquing (EJC)	Asking for evaluation (student-led)	"what do you think about what your friend says?
	Asking for evaluation (case-based)	"when we throw a metal coin into the water, it sinks, and a big ship does not. Why is that?"
	Asking for evaluation (teacher-led)	*
Challenging (CHAL)	Challenging (by playing devil's advocate role)	"Although I bend the wire, the electricity continues to pass."
	Praising student-led challenging	*
	Challenging (by monitoring)	"You say more than one sperm get to egg, but you just said one sperm gets to the egg."
Seeking for Evidence (SFE)	Praising use of evidence	*
	Prompting for EBR	"How do you know the earth isn't conducting electricity?"
	Referring in-text information (evidence)	*
	Asking for making attachment	*
Labelling and naming (LAN)	Asking for assigning labels	"What we call it (Fb) briefly?"
Inferencing (INF)	Asking for drawing conclusions	"What did you draw from this experiment?"
Ensuring mutual respect (EMR)	Asks for providing maintenance	"Let's listen to your friend's explanation, do not interfere, then ask your questions"

Note. Reprinted from "Fen öğretiminde öğretmenin söylemsel hamlelerinin öğrenenlerin akıl yürütme kalitelerine etkisi: Söylem analizi yaklaşımı," by Soysal, Y. 2019, *Journal of Qualitative Research in Education,* p. 1006-1007. *Not detected in this study.

In order to address the first research question, teachers' utterances were assigned to the code catalogue of TMDs. The teacher utterances were excluded from the data when the teacher talked about something not related to the lesson. To deal with inherent limitations of systematic observation, context was considered during the coding procedure. Firstly, teacher utterances were assigned to predetermined categories considering not only verbal talk but also non-verbal talk (for example, gesture, body movement, mimics etc.) since the non-verbal talk of teachers could change the categories of enacted discursive moves. For this reason, coding was carried out on not only transcriptions but also video-recordings. For example, what teachers say to "yes" nodding her head means the teacher accepts students' response. Secondly, the teacher utterances were coded within the context. This means that the same discursive moves in the implementation may correspond to the different purpose of discursive moves. Finally, study specific codes were added to the categories when necessary. After coding, the frequencies and percentage of TDMs were determined in both implementation levels to investigate fluctuations among discursive moves in different levels of ABI implementation.

3.4.2. The Framework of Communicative Approach

In order to address the second research question, each episode was assigned to the type of communicative approach. After coding, coded communicative approach was counted. The frequencies and percentages of communicative approach were determined in both implementation levels.

In the book of Meaning Making in Secondary Science Classrooms, Mortimer and Scott (2003) introduce five aspects of the analytic framework in an effort to describe discourse occurring in science classroom. These five aspects are as follows; 1) teaching purposes, 2) content, 3) communicative approach, 4) patterns of discourse and 5) teacher intervention (discursive moves). In this study, enacted communicative approach and discursive moves by teachers were handled in order to identify the differences between classroom discourse in medium and high levels of ABI implementations. In order to identify the type of communicative approach performed by teachers, the framework for analyzing the communicative approach was used in this study. There are four main classes of communicative approach that classifies the talk between students and teachers.

Scott, Mortimer and Aguiar (2006, p.611-612) defined the classes of communicative approach as can be seen below.

1. Interactive/dialogic: Teacher and students consider a range of ideas. If the level of interanimation is high, they pose genuine questions as they explore and work on different points of view. If the level of interanimation is low, the different ideas are simply made available.
2. Noninteractive/dialogic: Teacher revisits and summarizes different points of view, either simply listing them (low interanimation) or exploring similarities and differ- ences (high interanimation).
3. Interactive/authoritative: Teacher focuses on one specific point of view and leads students through a question and answer routine with the aim of establishing and consolidating that point of view
4. Noninteractive/authoritative: Teacher presents a specific point of view.

3.4.3. The Framework of Quality of Student Reasoning

In order to address the third research question, students' utterances were assigned to reasoning typologies of student response. This framework (Furtak et al., 2010; Hardy et al., 2010; Shemwell and Furtak, 2010) was developed based on previous studies in order to examine to what extent reasoning happened in the science classroom discourse (Furtak et al., 2010). The four elements of reasoning are as follows "premise, claim, data, evidence, rule" that characterize the main functions of teachers and students' utterances in the science classroom discourse (Furtak et al., 2010, p.18). The premise is the utterance's subject that includes the claims, whereas claims are usually defined as a verb that defines the situation of subject. For instance, the student utterance of "the stone will sink" includes a premise that is the subject of student utterance ("the stone"), and a claim that is the verb of the student utterance ("will sink"). The backing for the claim-premise utterance has been frequently indicated with the "because" in explicit or implicit ways. There are three types of backing of utterances; namely, data, evidence and rule. The detailed description of elements of reasoning is given in Appendix A. There are four types of reasoning as seen in Table 11. The least complicated reasoning includes any supporting; refers to *unsupported.* The partial reasoning only depends on data or evidence, refers to *phenomenological.* More complicated reasoning is supported by evidence with the comparing subjects referring to *relational*. The most complicated reasoning includes scientific reasoning, referring to *rule-based.*

Table 11. The Quality of Reasoning in Science Classroom Discourse

Quality of Reasoning	*Definition*	*Description*	*Diagram*
Unsupported	No reasoning	Elements of reasoning present, but no processes of reasoning; pseudo, circular, or tautological reasoning	Premise ← → Claim
Phenomenological	Data-based reasoning	Data applied to a claim	Premise ← → Claim ↑ Data
Relational	Evidence-based reasoning	Evidence applied to a claim, including analysis of data	Premise ← → Claim ↑ Evidence ↑ (Data)
Rule-based	Inductive or deductive rule-based	1. Deductive reasoning (top-down), applying a rule to make a claim with respect to a new premise 2. Inductive reasoning from data to rule 3. Applying a rule with new evidence (exemplifying with analogy) 4. Complete reasoning structure (whole framework)	Premise ← → Claim ↑ Rule ↑ (Evidence) ↑ (Data)

Note. Reprinted from "A framework for analyzing reasoning in science classroom discourse" by Furtak, E. M., Hardy, I., Beinbrech, T., Shavelson, R. J., & Shemwell, J. T., 2008, March. In *Paper to be presented at the Annual Meeting of the, American Educational Research Association, New York, NY.*

Students utterances were coded as out of coding in following situations 1) a lot of students talked at the same time (for example, it will sink, it will float), 2) students talked about the concepts unrelated to the topics, 3) student could not complete their sentence and 4) students' voice was not heard because of classroom noise. Moreover, students' utterances were coded within the context considering the previous, next students' utterance as well as teachers discursive moves. In this respect, coding was made by combining more than student's utterances belonging to the same student in following situations 1) teachers asked questions to students in order to extend students' response 2) students continued to talk after the teacher cut off students' response. In addition to evidence-based reasoning video framework (Furtak et al., 2010), students' questions that were asked to each other or to their teachers were also coded as type of the students' reasoning that was not included in the framework of quality of student reasoning. Finally, student's utterances were coded considering not only reasoning quality but also conceptual understanding. In other words, when the student utterances were not scientifically correct, it was coded as unsupported. First, when students' explanations were not consistent with the scientific view of knowledge (for example, "the gravity of liquid is less than air because of density difference"), their utterance was coded as unsupported. Second, when students could not support their claim with any backing (for example, "I think Huseyin's idea is illogical. We don't think we have to find what he says"), their utterance was also coded as unsupported. After coding, the frequencies and percentage of student reasoning quality were determined in both implementation levels.

3.4.4. Individual Case Analysis

The individual case analysis was carried out for Teacher A and Teacher B in order to addresses each research question. The fluctuations among teachers discursive moves and communicative approach enacted by teachers in different implementation levels were given with frequencies, percentages and excerpts. Moreover, the relationship between teacher discursive moves and students' reasoning quality was explained with frequencies and percentages regarding the different science contents.

3.4.5. Cross-Case Comparison

The cross-case comparison was conducted between the frequencies and percentages of Teachers A and Teacher B discursive roles and communicative approach as well as the relationship between students' reasoning quality and teacher discursive moves in both levels with the examples of ABI implementations. The aim of this comparison across the case was to identify similarities and differences of results of each case considering different science contents and students' grade levels.

3.5. Trustworthiness of the Study

In the qualitative study, there are three main factors for determining the trustworthiness of it. These are namely; credibility, transferability and dependability (Lincoln & Guba, 1985). The ways of addressing the factors in this study are explained below.

One of the significant factors is the establishing the credibility for ensuring trustworthiness of the study (Lincoln & Guba, 1985). This being the case, the technique of "peer debriefing" (Lincoln & Guba, 1985) is used. Guba (1981) defines peer debriefing as providing "inquirers with the opportunity to test their growing insights and to expose themselves to searching questions" (Guba, 1981, p. 85). During the analysis of the collected data and interpretation of the results, discussions were conducted with advisor of this study and academic staff in the field of science education to address the research questions.

Transferability is defined as to what extent the results of qualitative study is applied to another context (Merriam, 1998; Tobin & Begley, 2004). In this study, the transferability was established through 'purposeful sampling' and 'thick description' (Bitsch, 2005, p. 85). In order to reach the aim, this study included thick description of the PD program, teachers discursive moves, student' reasoning quality, coding procedures as well as the ABI implementation, which allowed other researcher to repeat this study in different settings. Moreover, two participant teachers were selected through purposeful sampling that offered deeper findings rather than other sapling methods (Cohen, Manion, & Morrison, 2011).

Dependability is described as "the stability of findings over time" (Bitsch, 2005, p.86). In this study, dependability was established utilizing "stepwise replication" and "code-recode strategy". The coding of teacher discursive moves, communicative approaches and students' reasoning quality was conducted by not only researcher but also external researches. Firstly, researcher coded the teacher utterance using the catalogue of TDMs and student utterance using evidence-based reasoning catalogue and compared their results. Moreover, the researcher discussed the result of the coding until reaching a 80% inter-rater agreement in the coding of TDMs, a 90% inter-rater agreement in the coding of communicative approach as well as a 90% inter-rater agreement in the coding of students' reasoning quality. Similar to coding, RTOP was scored by two researchers until reaching a 90% inter-rater agreement. Secondly, the coding of teacher and student utterance was conducted twice by researcher (author) in order to establishing intra-rater agreement.

CHAPTER 4

RESULTS

This chapter will introduce the main findings of the analysis described in the earlier chapter. The research questions given below will be addressed.

1. What are the discursive moves (TDMs) performed by teachers in the medium and high levels of ABI implementation?
2. What are the communicative approaches performed by teachers in the medium and high levels of ABI implementation?
3. What is the relationship between teachers' discursive moves and students' reasoning quality in medium and high levels of ABI implementation with different science contents?

For each research question, first, the findings of the teachers are presented as individual cases. Then, the similarities and differences in the teachers' performances are presented using cross-case analysis.

4.1. The Comparison of Discursive Moves of Teachers in Medium and High Levels of ABI Implementation

In order to address the first research question, the characteristics of the two teachers' level of ABI implementation are presented. Then, the relationships between characteristics of ABI implementation levels and the teachers' discursive moves are compared. Teachers' level of ABI implementation was determined with RTOP (Piburn et al., 2000). RTOP scoring range between 2 and 3 corresponds to medium level of ABI implementations and the range between 3 and 4 corresponds to high level of ABI implementations. In this study, teachers in medium and high levels of ABI implementation were characterized with respect to four categories of RTOP:

student voice, teacher role, problem solving and reasoning and questioning. Both of the teachers' ABI implementations were categorized as medium level for their first unit of teaching. For the second unit of teaching, their ABI implementations were categorized as high level. RTOP scoring of Teacher A and Teacher B in each level of ABI implementation is given in Table 12.

Table 12. The RTOP Scoring of Each Category in Teacher A's and Teacher B's Medium and High Levels of ABI Implementation

	Teacher A (6th grade)		Teacher B (8th grade)	
RTOP Categories	RTOP Scoring in Medium Level	RTOP Scoring in High Level	RTOP Scoring in Medium Level	RTOP Scoring in High Level
Student Voice	2.3	3.2	2.6	3.1
Teacher Role	2.4	3.5	2.8	3.2
Problem Solving and Reasoning	2.3	3.2	2.4	3.0
Questioning	2.6	3.4	2.3	2.9
General	2.4	3.3	2.5	3.0

The descriptions of RTOP categories for medium and high levels of ABI implementation are given below.

Medium Level of ABI Implementations: In terms of student voice as the first category for medium level of ABI implementation, interaction among students has been frequently observed in the classroom discourse. The teacher considers the students' prior knowledge to construct on and contribute to the topic that is already discussed in medium level of ABI implementation. Hence, many students are involved in discussion where the direction of lesson depends on students' ideas and questions. Students utilize at least two model representations (graphics, tables and models etc.) in one fourth of the lesson in medium level. As the second category, teacher role measures to what extent a teacher is "a resource person" and "teacher as listener" in the classroom discourse. In other words, this category examines how the teacher acts to students' response for promoting student thinking and how s/he guides students' investigation. In medium level of ABI implementation, teacher listens to the student's ideas; however, s/he also has a tendency to evaluate the students' responses. In addition, students are active within the boundaries of the teacher's teaching agenda in medium level.

As the third category, problem solving, and reasoning explains how the teacher promotes students' reflection, and how students are encouraged to find alternative solutions. Additionally, students are engaged in the analysis of phenomenon by comparing and contrasting ideas in medium level. As the last category, teacher questioning determines how the teacher prompts her/his questions in the classroom discourse. The teacher asks questions that encourage students to evaluate each other less in medium level.

High Level of ABI Implementations: In terms of student voice, the students talk with each other more frequently in the classroom discourse during high level of ABI implementation. Moreover, the teacher stimulates students' prior knowledge before introducing the topic and opens the topic based on their knowledge. Therefore, most of the students are involved in a discussion where students' ideas and questions determine the flow of the lesson. Moreover, the students use different modal representations more frequently in the classroom discourse. As regards teacher role, teachers not only listen to students' ideas but also expand their ideas by giving feedback on their response. In addition, the teacher facilitates student involvement in their learning process depending on the students' ideas. With respect to problem solving and reasoning, the students made reflection on what they learn more frequently in high levels of ABI implementation. As regards teacher questioning, teachers intend to ask questions that encourage students to evaluate each other more frequently in high levels.

The teachers' discursive moves were coded by using Soysal's (2019) code catalogue of TDMs. However, when it was necessary, codes (i.e., throw, modelling) were added by considering other studies (Soysal, 2017; 2018; Soysal & Yilmaz-Tuzun, 2019). Moreover, the new codes were emerged from the data analysis of this study. These codes are asking for recalling, asking for alternative response and passive re-voicing. The observed TDMs in this study is given with the detailed description and the examples in Appendix B.

For both teachers, the teacher discursive moves were observed in ten categories: (1) knowledge providing and evaluation (KPE), (2) science process skills (SPS), (3) communicating (COM), (4) monitoring and framing (MOF), (5) reflective discourse (RED), (6) challenging (CHAL), (7) seeking for evidence (SFE), (8) modelling (MOD), (9) labelling and naming (LAN) and 10) ensuring mutual respect (EMR). Various discursive moves enacted by Teacher B in the medium level of ABI implementation are given in Table 13.

Table 13. The Example of the Different Discursive Moves Performed by the Teacher B

Turn	Speaker	Utterance	Discursive Moves
213	T	Are we talking about the egg membrane?	Requesting for clarification
214	S	Teacher, cell membrane	No Coding
215	T	Cell membrane // Yes, aren't we talking about cells here? We're talking about the egg cell.	Accepting//Monitoring (on-moment)
216	S	Yes	No Coding
217	T	Is that so? Your friend says that the membrane of the egg cell can be torn. He says there's something coming in. Do you think it can be torn?	Monitoring (Retro)/Asking for evaluation (student-led)
218	S	No	No Coding
219	T	Does it enters the egg without being torn? How does the egg enter into the cell? // Do you think it is torn? Saniye?	Probing//Embodying //Asking for making prediction
220	S	Yes it does, they said that one sperm enters the egg, then how is the twin child formed?	No Coding
221	S	They enter at the same time.	No Coding
222	T	Two sperms may be entering at the same time.	Accepting
223	S	There's only one sperm coming in.	No Coding
224	T	A friend of yours just said there's only one. Who was that?	Monitoring (retrospective)
225	S	Me	No Coding
226	T	It was Mehmet. Then how are twins formed?	Challenging (devil)

This example is taken from Teacher B's medium level of ABI implementation.

4.1.1. Teacher A

The frequencies and percentages of occurrence of the discursive moves enacted by Teacher A in the medium and high levels of ABI implementation are given in Table 13. Although the majority of the discursive moves was the COM (34% in the high level, 40% in the medium level) in both levels of ABI implementations, CHAL, SFE, MOD, LAN and EMR discursive moves were rarely or never performed.

Table 14. The Frequency and Percentage of TDMs in Both Levels of Teacher A

Categories and Subcategories of TDMs	Medium Level		High Level	
	Frequency	Percentage	Frequency	Percentage
Knowledge Providing & Evaluating (KPE)	**54**	**24**	**19**	**10**
Presenting logical expositions	10	4	3	2
Affirming	30	13	13	7
Rejecting	0	0	0	0
Verbal cloze	8	4	2	1
Asking for recalling	6	3	1	1
Science Process Skills (SPS)	**38**	**17**	**27**	**15**
Asking for simple comparison	17	8	15	8
Asking for making prediction	20	9	8	4
Asking for making observations	1	0	4	2
Asking for establishing inference	0	0	0	0
Communicating (COM)	**75**	**34**	**74**	**40**
Probing	26	12	25	13
Asking for alternative response	3	1	5	3
Requesting for clarification	14	6	7	4
Reformulating	2	1	18	10
Passive re-voicing	18	8	19	10
Embodying	12	5	0	0
Monitoring & Framing (MOF)	**41**	**18**	**38**	**20**
Focusing	8	4	6	3
Monitoring (type-1: on-moment)	15	7	14	8
Monitoring (type-2: prospective)	1	0	6	3
Monitoring (type-3: retrospective)	9	4	6	3
Summarizing	8	4	6	3
Challenging (CHAL)	**2**	**1**	**0**	**0**
Challenging (by playing devil's advocate role)	2	1	0	0
Challenging (by monitoring)	0	0	0	0
Reflective Discourse (RED)	**3**	**1**	**18**	**10**
Asking for evaluation (student-led)	1	0	12	6
Asking for evaluation (case based)	2	1	0	0
Asking for evaluation (teacher-led)	0	0	0	0
Throwing	0	0	6	3
Seeking for Evidence (SFE)	**1**	**0**	**1**	**1**
Modelling (MOD)	**0**	**0**	**3**	**2**
Labelling and Naming (LAN)	**1**	**0**	**0**	**0**
Ensuring Mutual Respect (EMR)	**8**	**4**	**6**	**3**
TOTAL	223	100	186	100

Moreover, the fluctuation in the teacher's discursive moves through his pedagogical progression is also shown in Figure 1. The change of teacher discursive moves in different levels of ABI implementation is discussed with Teacher A's RTOP scoring in each category as mentioned earlier. The change in the percentages of TDMs is explained as follows; the highest and lowest changing or unchanging percentages in the teacher discursive moves by considering the categories of TDMs. However, when the sub-categories of TDMs were examined, there were also the highest changing percentages in the some moves (i.e., affirming, asking for prediction, reformulating, embodying and asking for evaluation student-led) toward Teacher A's pedagogical improvement toward ABI.

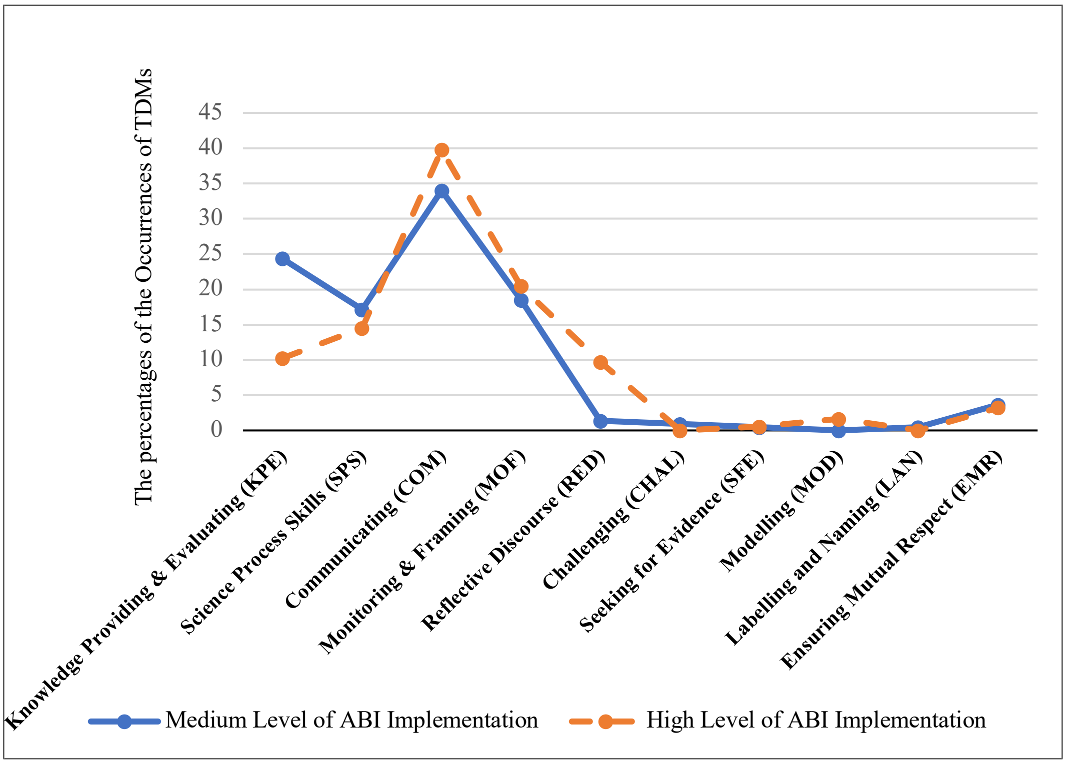

Figure 1. The Fluctuation in the Discursive Moves Through Teacher A's Pedagogical Progression

4.1.1.1. The Highest Changing Percentages in Teacher Discursive Moves

Communicating (COM), reflective discourse (RED) and knowledge providing and evaluating (KPE) moves were the highest changing percentages in teacher discursive moves when Teacher A's level of ABI implementation improved from medium to high level. The highest increasing percentages were observed in RED (9%) and COM (6%) moves while the highest decreasing percentage was observed in KPE (14%) through pedagogical progression of Teacher A. This showed that as the Teacher A's level of ABI implementation improved, the teacher focused on the underlying meaning of students' responses and conducted reflective discourse more frequently instead of giving information or evaluating student's responses against scientific points of view. It is discussed how changing of these three moves might be related to Teacher A's RTOP scores in categories that are *student voice, teacher role, problem solving and reasoning and questioning.*

In medium level of ABI implementation, one in Teacher A's four moves was the KPE. However, one in his ten moves was the KPE in high level of ABI implementation. Upon examining the sub-categories of KPE moves, it seemed that the affirming/accepting move was the highest decreasing (7%) with respect to the increasing implementation level of the teacher. In each implementation level, the teacher did not use the rejecting discursive move. This improvement of the teacher was important for ABI implementation. The changing percentage of KPE moves might be related with the increasing RTOP scoring in the category of student voice, teacher role and problem solving and reasoning. The teacher might effectively use students' responses to trigger their prior knowledge by less frequently affirming student's response, by presenting logical exposition and by asking for recalling in high level of ABI implementation. Therefore, students might more often expand their ideas by engaging actively in dialogical interaction with their peers and the teacher in the high level. When looking into the sub-categories of COM moves, the increase seemed to emerge from probing, asking for an alternative response, passive re-voicing and reformulating moves since the percentages of requesting for clarification and embodying moves in the high level were less than those of medium level. In addition, reformulating move was the highest increasing percentage (9%) while embodying move was the highest decreasing percentage (5%). When the teacher A had an effort to create the classroom discourse in which teachers and students communicated each other especially by reformulating students' utterance more often in high level of ABI implementation, the RTOP scoring in all categories might increase. When the students' utterances were more frequently transformed to more comprehensible one for students by the Techer A, their ideas were more likely to determine the flow of the lesson since healthier communication in the classroom enabled the students to contribute to the classroom discourse.

It was observed that the frequency of RED discursive moves in the high level was 15 times more than those in the medium level. In both of the implementation levels, teacher-led evaluation was not carried out. The highest increase (6%) in the percentage of sub-categories of reflective discourse occurred in the asking for evaluation (student-led) move. This implied that when the teacher implemented ABI more efficiently, he guided the students more frequently not only to evaluate each other's ideas by criticizing and asking questions but also to give the responsibility to the students for their learning. The highest change in the percentage of RED moves can be related to increasing RTOP scoring in all categories which are problem solving and reasoning, student voice, teacher role and teacher questioning. When the teacher A conducted RED moves more frequently, the teacher role might be more "listener" and thus their questions of RED moves might increase the negotiation among students and promote students' alternative thinking. Therefore, the quality and quantity of students' involvement in dialogic interaction with their peers (defined as a student voice) increased in the Teacher A's high level of ABI implementation.

4.1.1.2. The Lowest Changing and Unchanging Percentages in Teacher Discursive Moves

Science process skills (SPS) (2% less), monitoring and framing (MOF) (2% more), challenging (CHAL) (1% less), seeking for evidence (SFE) (1% more), modelling (MOD) (%2 more), and ensuring mutual respect (EMR) (1% less) were the lowest changing. In addition, labelling and naming (LAN) was the unchanging percentages in the teacher discursive moves when the teacher A's level of ABI implementation improved from medium to high level.

Even though SPS and MOF moves were performed at least 15% in both implementation levels of the Teacher A, these moves were the lowest changing percentages in different implementation levels. When looking into sub-categories of SPS moves, the change in the percentage of asking for prediction was the highest decreasing percentage (%5). The teacher did not perform asking for establishing inference in both levels. Students were required to perform science process skills since they conducted scientific investigation during ABI implementation. When the percentages of the sub-categories of MOF discursive moves were investigated, all moves in the MOF category were the lowest changing percentages. However, MOF moves were dominant in both levels. This meant that Teacher A promoted the student to be aware of what happened in the classroom discourse by means of monitoring, framing and summarizing moves. Although MOF and SPS moves, dominant in both levels, might not directly be related with the RTOP categories, these moves were pre-organizer to allow the behaviors in RTOP categories to occur more efficiently in the classroom discourse.

CHAL, SFE, MOD, EMR and LAN were performed less than 5% in both implementation levels of the Teacher A. CHAL moves were expected to increase in high level of ABI implementation; however, it did not happen in this study. The challenging moves were related to all RTOP categories. Moreover, teacher content knowledge and unit preparation before the implementation are also important to present the counter arguments about the students' utterance to them. However, modified RTOP does not evaluate the teacher content knowledge. It was also expected to increase the percentage of seeking for evidence moves in high level of ABI implementation. Although the moves were directly related with the RTOP category, problem solving and reasoning, there was no change in the percentage of SFE. It can be concluded that teacher still struggled with performing CHAL and SFE moves in high level. The modelling discursive moves are performed by the teacher when he needs to model how a scientist works (for example, controlling variables and making claims so on) considering students' prior knowledge. This move was not directly related with the RTOP categories. Therefore, the Teacher A did not need to display MOD move more frequently in high level of ABI implementation. The percentage of LAN in the both levels was zero. However, the teacher performed one LAN discursive move in the medium level. This move also was not directly associated with the RTOP categories. The EMR move is performed when it is needed for the classroom management. This move had no direct relevance with the categories of RTOP.

4.1.2. Teacher B

The frequencies and percentages of occurrence of the discursive moves enacted by Teacher B in the medium and high levels of ABI implementation are given in Table 15. In both levels, she mostly focused on the communicating (COM) discursive moves (45% in the high level, 40% in the medium level). The percentages of the occurrence of the discursive moves, CHAL, SFE, MOD, LAN and EMR, were less than 5% in both of the implementation levels.

Table 15. The Frequency and Percentage of TDMs for in Both Levels of Teacher B

Categories and Subcategories of TDMs	Medium Level		High Level	
	Frequency	Percentage	Frequency	Percentage
Knowledge Providing & Evaluating (KPE)	**39**	**12**	**24**	**8**
Presenting logical expositions	4	1	5	2
Affirming	29	9	15	5
Rejecting	2	1	1	0
Verbal cloze	1	0	1	0
Asking for recalling	3	1	2	1
Science Process Skills (SPS)	**53**	**16**	**52**	**17**
Asking for simple comparison	12	4	27	10
Asking for making prediction	33	10	14	5
Asking for making observations	5	2	6	2
Asking for establishing inference	3	1	5	2
Communicating (COM)	**144**	**45**	**121**	**40**
Probing	44	14	41	14
Asking for alternative response	6	2	5	2
Requesting for clarification	23	7	21	7
Reformulating	29	9	24	8
Passive-revoicing	38	12	27	9
Embodying	5	2	3	1
Monitoring & Framing (MOF)	**72**	**22**	**57**	**19**
Focusing	29	9	17	6
Monitoring (type-1: on-moment)	16	5	11	4
Monitoring (type-2: prospective)	4	1	1	0
Monitoring(type-3: retrospective)	10	3	21	7
Summarizing	13	4	7	7
Challenging (CHAL)	**4**	**1**	**3**	**1**
Challenging (by playing devil's advocate role)	3	1	3	1
Challenging (by monitoring)	1	0	0	0
Reflective Discourse (RED)	**7**	**2**	**23**	**8**
Asking for evaluation (student-led)	5	2	14	5
Asking for evaluation (case based)	1	0	1	0
Throw	1	0	8	3
Seeking for Evidence (SFE)	**2**	**1**	**2**	**1**
Modelling (MOD)	**0**	**0**	**8**	**3**
Labelling and Naming (LAN)	**0**	**0**	**1**	**0**
Ensuring Mutual Respect (EMR)	**3**	**1**	**8**	**3**
TOTAL	**325**	**100**	**299**	**100**

Moreover, the fluctuation in the Teacher B's discursive moves through her pedagogical progression is also shown in Figure 2. For the Teacher A, the teacher discursive moves in the different levels of ABI implementation are discussed with the RTOP scoring in categories. The comparison of discursive moves of the teacher in medium and high implementation levels is discussed under two headings as follows: the highest changing percentages in TDMs and the lowest changing or unchanging percentages in TDMs. However, when the sub-categories of TDMs were examined, there were the highest changing percentages in the some moves (i.e., affirming, asking for prediction, asking for comparison and monitoring (retrospective)) through Teacher B's pedagogical progression.

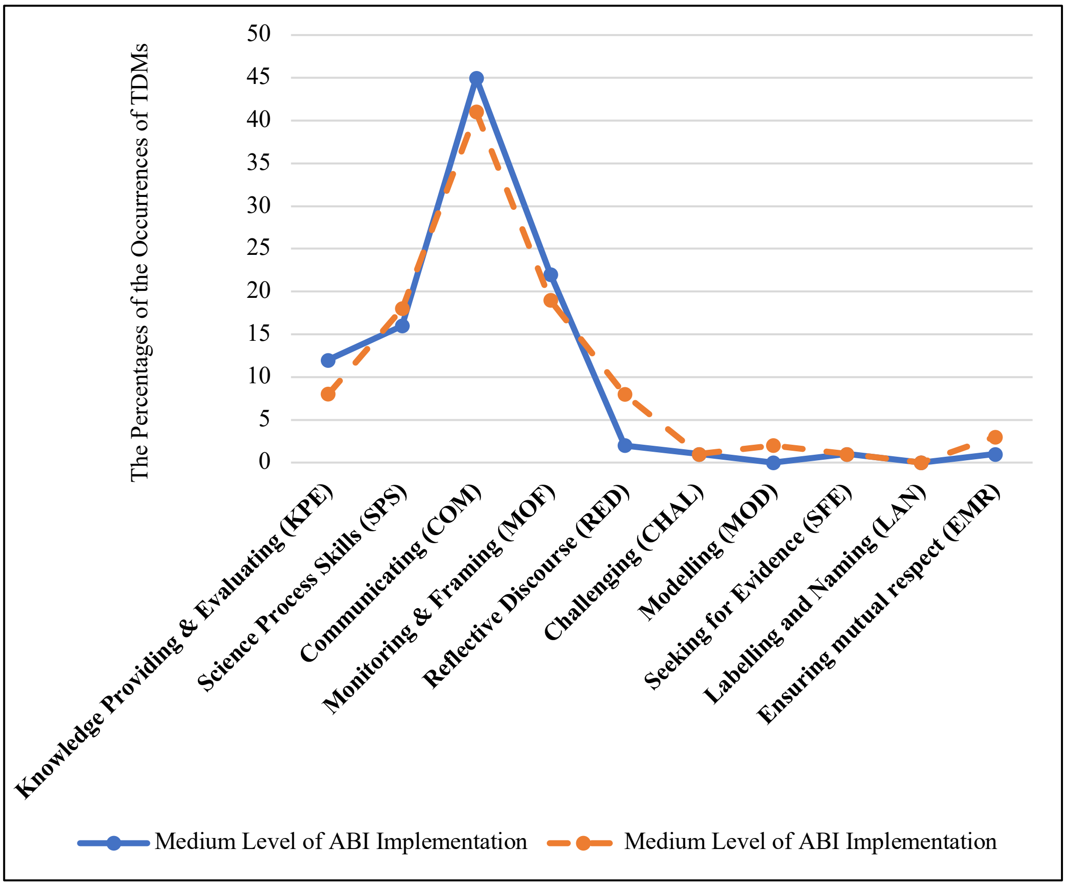

Figure 2. The Fluctuations in the Discursive Moves Through Teacher B's Pedagogical Progression

4.1.2.1. The Highest Changing Percentages in Teacher Discursive Moves

Communicating (COM), reflective discourse (RED) and knowledge providing and evaluating (KPE) moves were the highest changing percentages in the teacher discursive moves when the teacher implemented ABI more effectively. The highest increasing percentage was observed in RED (6%), while the highest decreasing percentages were observed in COM (5%) and KPE (4%) moves, respectively with respect to the increasing level of the ABI implementation. The relationship between the highest changing percentages and RTOP scoring in each category was examined in medium and high levels of ABI implementation.

On looking into sub-categories of KPE, the differences appeared to emerge from affirming and rejecting moves. Moreover, affirming move was the highest changing percentage (4%). As the teacher evaluated students' response by affirming or rejecting less frequently, the RTOP scoring in categories of student voice, teacher role and problem solving and reasoning might improve. In other words, the change in the evaluation move of triadic pattern might have a potential to increase the student-student interaction and students' reflection on their learning by encouraging them think about their and peers' ideas.

When examining the sub-categories of COM moves, the percentages of occurrence of the probing and asking for alternative response moves were the same both in the medium and high level. On the other hand, the percentages of other discursive moves enacted in the high level were less than those in the medium level. It was expected to increase the quantity of COM moves in high level. However, the lowest changing percentage of sub-categories might not be associated with the students' pedagogical progression.

Teacher B conducted 16 times more reflective discourse in the high implementation level. The percentages of asking for the evaluation (student-led) and throwing in high level were greater than those in the medium level. However, the teacher did not perform the asking for evaluation (teacher led) in both levels. The highest increasing RED was related to the RTOP scoring in all categories.

4.1.2.2. The Lowest Changing and Unchanging Percentages in Teacher Discursive Moves

Science process skills (SPS) (1% more), monitoring and framing (MOF) (3%less), modelling (MOD) (3% more), and ensuring mutual respect (EMR) (2% more) were the lowest changing. In addition, labelling and naming (LAN), challenging (CHAL) and seeking for evidence (SFE) were the unchanging percentages in the teacher discursive moves when teacher A's implementation level of ABI improved from medium to high.

Although SPS and MOF moves were performed at least 15% in both implementation levels of Teacher B, these moves were the lowest changing percentages in the different implementation levels. When the sub-categories of SPS moves were examined, it was seen that when the highest increasing percentage was the asking for comparison move (6%), the highest decreasing percentage (5%) was the asking for making prediction move. When looking into the sub-categories of MOF moves, the highest increasing percentage (4%) was the retrospective moves through her pedagogical improvement. SPS and MOF moves which were predominant in both levels might be a pioneer condition for all RTOP categories.

CHAL, SFE, MOD, EMR and LAN were performed less than 5% in both implementation levels of Teacher B. Teacher B had a difficulty in increasing the percentages of challenging moves. This might be due to the teacher's content knowledge. The percentages and frequencies of the SFE discursive moves were the same in medium and high levels. The move was expected to increase in the high level since she should be more likely to promote the students to make claims based on evidence during the ABI implementation. Although SFE move was associated with RTOP category "problem solving and reasoning", there was no change in percentages of SFE moves. The MOD, EMR and LAN moves did not correspond to the behaviors in RTOP categories. These moves depend on the need of classroom discourse and the purpose of the instruction. For example, if students have a difficulty in controlling variable in the experiment, MOD moves can be displayed. Moreover, if teachers need to reach a consensus about naming of concepts during the negotiation, LAN move can be performed. Finally, if there needs to make sure about classroom discourse for the sake of the classroom management, EMR might be enacted when necessary.

4.1.3. The Results of Cross-Case Analysis

For the first research question, the similarities and differences of the discursive moves enacted by Teacher A and Teacher B in the medium and high implementation levels are given below. Although the Teacher A and Teacher B implemented ABI with different science topics in different grade levels, the fluctuations of discursive moves in the both levels for each case shared some similarities. First, when the implementation levels of Teacher A and Teacher B rose from medium to high, both teachers conducted more reflective discourse through the asking for evaluation and throwing. This indicated that the teachers in the high level encouraged students to evaluate and judge others' ideas through the ABI implementation more than in the medium level. Additionally, the most increasing percentage was the reflective discourse among the all discursive moves with respect to the increasing level of the ABI implementations for each case. Also, both teachers gave information and evaluated students' response less in their high levels of ABI implementation through their pedagogical improvement. The difference of changing ratio in RED and KPE moves might be associated with the difference of RTOP scoring in categories as provided in Table 12. In this study, there was a relationship between higher changing percentages in Teacher A's RED and KPE moves and the higher changing RTOP scoring in categories. Second, CHAL, SFE, MOF, MOD, EMR, LAN and SPS moves were the lowest or unchanging percentages in both teachers' different levels of ABI implementation. Third, it can be concluded that CHAL, SFE, MOD, LAN and EMR discursive moves were seldom performed in both teachers' different implementation levels of ABI since the percentages of these discursive moves in the both levels were less than 5% with the different trends of change. Finally, the majority of the discursive moves was the COM in both levels as over 33%. This implies that during the ABI implementation, the teachers had a tendency to comprehend the meaning behind the students' utterances and make students' utterances more understandable and accessible to other students. Moreover, SPS and MOD moves were dominant in both levels of ABI implementation for each case.

Even though both teachers' implementation level improved, the changing of discursive moves in both levels have a difference. The trends of change seemed different across the cases although COM was the highest changing percentage in each case. While the Teacher A performed the COM discursive moves 6% more in the high level than those in the medium level, the Teacher B performed 5% less in the high level than in the low level.

4.2. The Comparison of Communicative Approach of Teachers in Medium and High Levels of ABI Implementation

To address the second research question, episodes of implementations were coded in accordance with the four classes of the communicative approaches (interactive/authoritative, non-interactive/authoritative, interactive/dialogic, non-interactive/dialogic) and were counted. For the second question, the types of communicative approaches performed by the teachers in both levels are explained.

4.2.1. Teacher A

The aspects of communicative approach are interactive/authoritative (IA), non-interactive/authoritative (NIA), interactive/dialogic (ID) and non-interactive/dialogic (NID). The types of the communicative approach performed by the Teacher A are given in Figure 3.

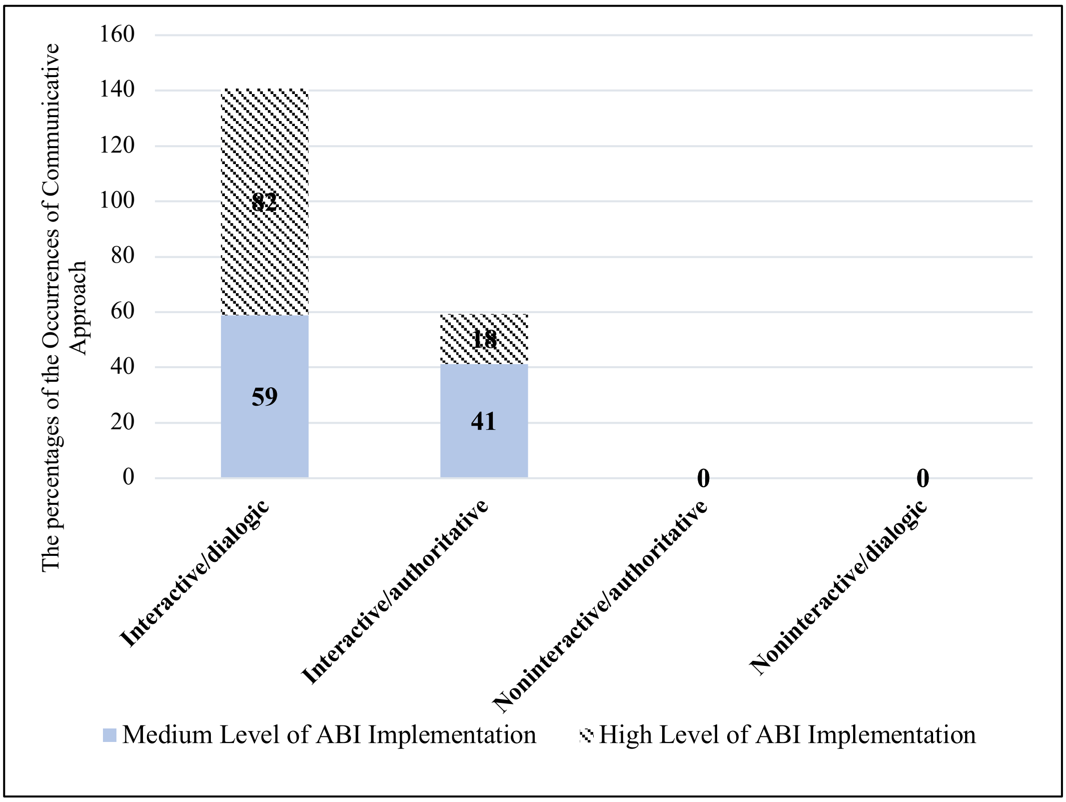

Figure 3. The Types of Communicative Approaches Enacted by the Teacher A in Both Levels

As seen in Figure 3, the interactive/dialogic communicative approach was the most common form of conversation through the ABI implementation. The interactive/dialogic communicative approach used in the high level of ABI implementation was 23% more than that in the medium level. On the other hand, the Teacher A utilized an interactive/authoritative approach 23% less in the high level. Moreover, any non-interactive talk (non-interactive/authoritative and non-interactive/dialogic communicative approach) was not observed in both levels. This implied that the teacher allowed the participation of students in the classroom talk in both levels. In addition, the teacher took students' opinions into account more frequently in high level. On the other hand, the teacher directed instructional questions in order to reach the point of view more frequently in medium level. In both levels, the teacher did not wrap up the lesson considering various ideas (non-interactive/ dialogic).

The example of interactive/authoritative communicative approach is given in Table 16. In the example, the aim of the teacher was to reach a specific point of view. Therefore, the teacher asked questions to get an answer that he has had in his mind. The students' responses were restricted to a single explanation ("upward", "yes", "gravity", "opposite direction").

Table 16. The Example of the Interactive/Authoritative Communicative Approach of Teacher A

Turn	Speaker	Utterance	Discursive Moves
200	T	Which direction is the direction of the buoyancy? Let's raise a finger and talk.	Open-ended question
201	S	Upward	No Coding
202	T	Yes up // Can we mark this? For example, let there be an object on the surface of the liquid //Which direction is the direction of the buoyancy?	Accepting//Focusing /on moment)//Embodying//Asking for recalling
203	S	Up	No Coding
204	T	Let's sign. The Buoyant. Okay?	Focusing
205	S	Yes	No Coding
206	T	Let's call it shortly	Asking for assigning labels
207	S	The Buoyancy force ($F_{b)}$	No Coding
208	T	Let us briefly show the symbol. We say ($F_{b)}$ doesn't matter. Well, what's pulling it down?	Presenting logical exposition//Asking for making prediction
209	S	Gravity Force	No Coding
210	T	Let's remember gravity from yesterday. // If gravity on the surface affects a mass, which property of that object is revealed? The force of gravity acting on an object would reveal which property of the object?	Monitoring (retrospective)//Asking for recalling
211	S	Gravity Force	No Coding
212	T	Okay // Gravity pulls this object downwards // We said that this is different on world and in moon.	Accepting//Presenting logical exposition//Asking for recalling
213	S	Weight.	No Coding

This example is taken from Teacher A's medium level of ABI implementation.

The example of interactive/dialogic communicative approach is given in Table 17. In the example, the teacher focused on exploring different students' views in the classroom talk.

Table 17. The Example of the Interactive/Dialogic Communicative Approach of Teacher A

Turn	Speaker	Utterance	Discursive Moves
88	S	Teacher, is there any difference between the height or speed of sound?	Student initiate
89	T	Your friend says "Is there any difference between the height or speed of sound?	Focusing
90	S	I think there is a difference.	No Coding
91	S	In addition, when it is slow, there is a difference.	No Coding
92	S	I think there is a difference between the strength of item.	No Coding
93	T	the difference exists.	Passive re-voicing
94	S	I want to answer what he says. When someone speaks, for example, if they speak in a low tone of voice, the sound waves will decrease a little more. That's why it changes. The sound wave is also directly proportional to the volume of the sound. The sound wave may also increase, or it can also fall down	No Coding
95	T	What do you mean by intensity? What does the intensity of sound mean?	Probing
96	S	I mean the frequencies.	No Coding
97	T	Is frequency the same thing as intensity?	Probing
97	S	No	No Coding
99	S	Teacher, amplitude, multiplicity.	No Coding
100	T	What does intensity mean?	Probing
101	S	Teacher, there is no any relationship between frequency and intensity.	No Coding
102	T	You mean they ara different	Reformulating
103	S	Yes, I know they are different.	No Coding

This example is taken from Teacher A's high level of ABI implementation.

4.2.2. Teacher B

The comparison of the type of communicative approach enacted by the teacher is given in Figure 4.

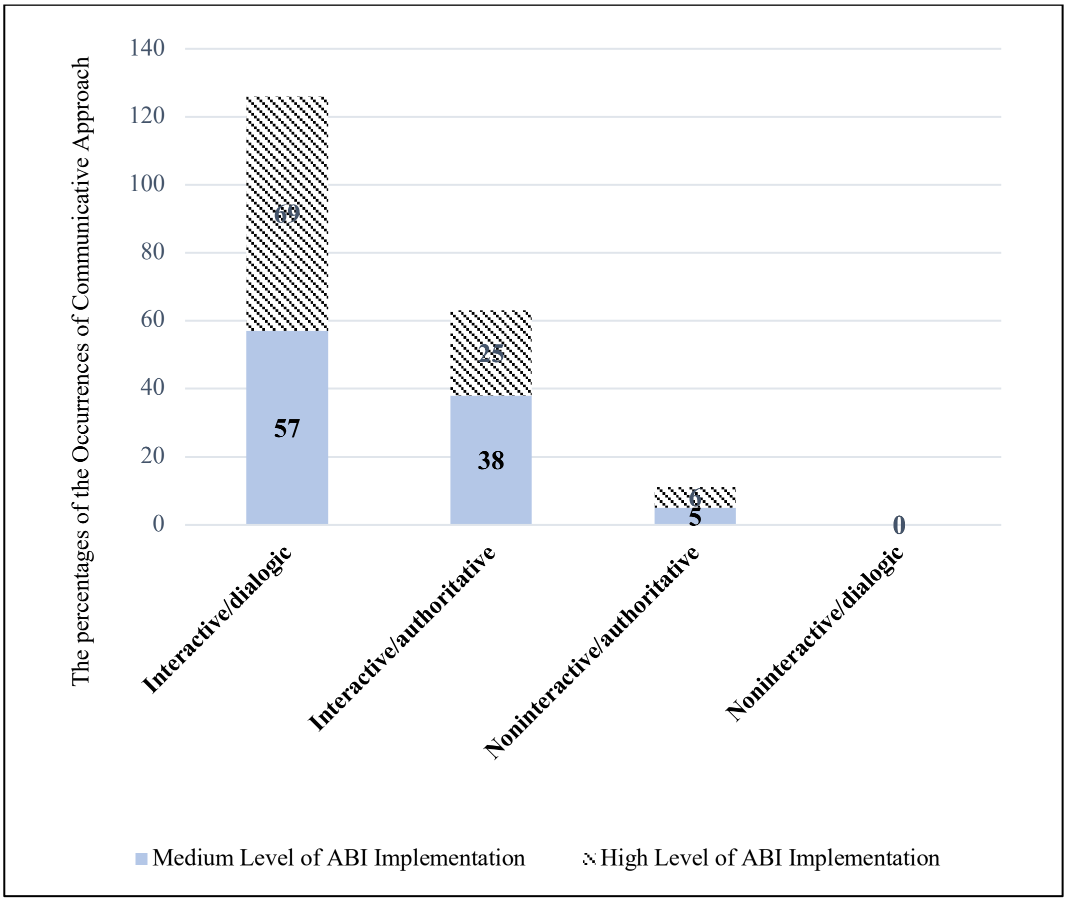

Figure 4. The Types of Communicative Approaches Enacted by Teacher B in Both Levels

The teacher B performed more interactive/dialogic communicative approach and a less interactive/authoritative communicative approach in the high level of ABI implementation. This means that as the implementation level of the teacher improved, more points of view were paid attention in the teacher-students as well as student-student interaction. Additionally, the teacher used the non-interactive/authoritative approach only once in both levels. Each implementation level had a common characteristic that the teacher allowed students to participate in the classroom talk which was referred to as "interactive". The example of non-interactive/authoritative communicative approach is given in Table 18. In the example, the teacher had an effort to introduce the concept "zygote" to students. In this episode, teacher did not invite students to discuss about the concept.

Table 18. The Example of the Non-interactive/Authoritative Communicative Approach of Teacher B

Turn	Speaker	Utterance	Discursive Moves
280	S	Zygote forms after sperm enters to egg	No Coding
281	T	Your friends said that "zygote forms after sperm enters to egg".	Focusing
282	S	What is the Zygote?	No Coding
283	T	He says, "what is zygote?"// Your friend said that "zygote forms after sperm enters to egg". Zygote is the concept. Scientists refer the union of the sperm cell and the egg cell as zygote".	Focusing//Presenting logical exposition

This example is taken from Teacher B's medium level of ABI implementation

4.2.3. The Results of Cross-Case Analysis

For the second research question, similarities and differences of communicative approach enacted by the Teacher A and the Teacher B in the medium and high implementation level are given below. In each case, teachers adopted a more interactive/dialogic approach and a less interactive/authoritative approach through teachers' pedagogical progression. Moreover, each teacher did not perform the non-interactive/dialogic communicative approach in both levels. Unlike Teacher A, Teacher B performed the non-interactive/authoritative approach in the both levels.

4.3. The Relationship Between Discursive Moves of Teachers and Students' Reasoning Qualities in Medium and High Levels of ABI Implementation

As part of the third research question, students' utterances were coded by using evidence-based video framework (Furtak et al., 2010).

4.3.1. Teacher A

The percentages of students' reasoning qualities varied across Teacher A's different levels of ABI implementation as seen in Figure 5. As the implementation level of the Teacher A increased, students performed relatively more sophisticated reasoning. The change in the percentage of TDMs might be associated with the change in percentage of the students' reasoning qualities in different levels of ABI implementation with different science contents. In addition to evidence-based reasoning video framework (Furtak et al., 2010), students' questions that they asked to their teacher and peers were also coded as type of the students' reasoning.

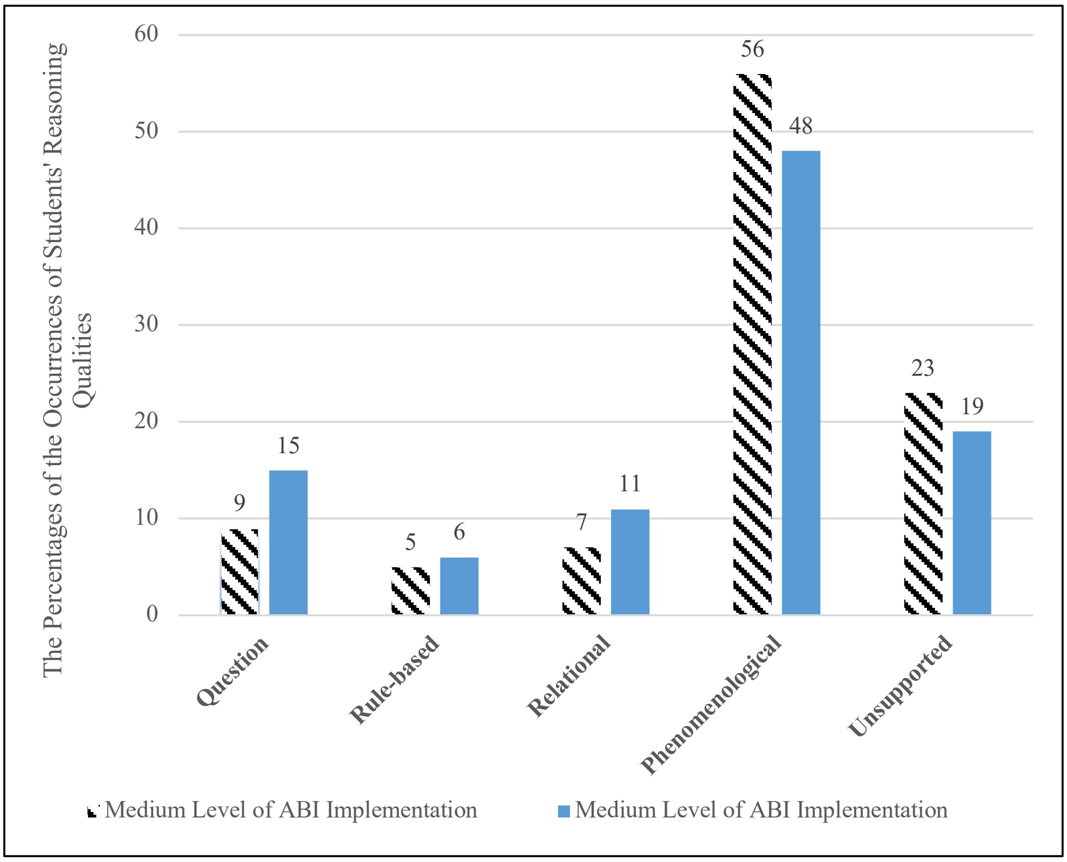

Figure 5. The Percentages of Students' Reasoning Qualities in Teacher A's Medium and High Levels of ABI Implementation

As seen in Table 19, during turn 35, the student made claims by backing with contextualized relationship between objects' falling speed in water and air, and density of water and air. Moreover, during turn 37, the student generated an unsupported claim which was scientifically incorrect knowledge. During turn 41, the reason why the velocity of objects in air and water was different was explained with a scientific principle. During turn 45, the student supported their claims only with their observation (data-based reasoning).

Table 19. The Example of Students' Reasoning Qualities with the Content "Buoyancy" in Teacher A's Class

Turn	Speaker	Utterance	Student Reasoning Quality
35	S	You know, we gave a coin as an example. It comes to the ground faster in the air, but, inside the water a certain amount of speed decreases because the density of the liquid and the density of the air is not the same.	Evidence-based
36	T	I asked about gravity. Density is different, okey.	No Coding
37	S	It is also different according to gravity.	Unsupported
41	T	it is the same because gravity is the same in both liquid and air. The force that pushes the coin is the same. However, it affects the speed of the coin because the intensity is different,	Rule-based
44	T	As your friend just said, there's the same gravity. However, the density of the coin determines the objects' falling speed.	No Coding
45	S	Yes, the intensity is different.	Data-based

This example is taken from Teacher A's medium level of ABI implementation.

Teacher A performed knowledge providing and evaluation (14% less) (KPE) less frequently but reflective discourse (9% more) (RED) and communicating (6% more) (COM) moves more frequently in high implementation level than those in medium implementation level. The decrease in the percentage of KPE moves might be related to the more sophisticated reasoning quality. The students made more sophisticated explanations more about the concept when the teacher did not evaluate the student's response by accepting or rejecting and did not provide scientific knowledge. The increase in the percentage of the RED moves might influence not only students' asking questions but also their reasoning qualities positively since asking for evaluation or throwing moves provided an opportunity for students to evaluate their peers' views by prompting questions and justifying their claims. The increase in the percentage of COM moves might be related with the students' reasoning qualities since these moves allowed the classroom discourse to be clear and healthy for both students and teachers. Moreover, while the reflective discourse moves had a potential to increase the percentage of students' questioning in high level implementation, the change in the percentage of COM and KPE might be also related with the increasing number of students' questioning.

In each implementation level, the majority of student reasoning qualities was the phenomenological (56% in medium level, 48% in high level) and unsupported (23% in medium level, 19% in high level). However, as the most sophisticated reasoning, the frequency of rule based was the least in the both levels (5% in medium level, 6% in high level). This common trend might be related with RED moves that were less frequently enacted as well as CHAL and SFE moves which were almost never performed in both implementation levels. Although the majority of TDMs enacted by the Teacher A was COM moves in both levels, only these moves might not be sufficient for students' more sophisticated reasoning qualities. COM moves should be supported with the CHAL, RED and SFE moves in order to increase the students' reasoning quality due to the fact that these moves provoke students to justify their claims with evidence and scientific principles in order to convince their peers and teacher about the validity of their claim.

When the contents of the ABI implementations were examined, it was obvious that students in Teacher A's class were likely to use their social language of science in both implementation levels. The overuse of social language of science might limit students to give more sophisticated reasoning since the teacher less frequently provided an opportunity for the students to be aware of the difference between their social language and scientific point of view through CHAL, RED and SFE moves. In the "buoyancy" implementation, while students discussed the objects' sinking and floating, they are likely to use their social language "the lighter object, objects with holes and objects with the large surface area will float" rather than the scientific point of view "the density of object and liquid determines whether object will sink or float". As given in Table 20, during turns 53, 55 and 57, students explained the reasons for the ship's floating using their social language. However, the teacher did not challenge with the student's idea in during turn 54 by offering the counter arguments like "when you put a bottle in water, it will float whether you put it vertically or horizontally".

Table 20. The Example of Students' Reasoning Qualities with the Content "Buoyancy" in Teachers' A Class

Turn	Speaker	Utterance	Student Reasoning Quality
52	T	He says it's the buoyancy of water, Zeynep?	No Coding
53	S	the ships both float in the water and contain air.	Unsupported
54	T	within the ship?	No Coding
55	S	yes, there is also air. It floats and never sinks because of the air within the ship	Unsupported
57	S	I think the pressure of ship is less because of its surface area. For example, while standing, we exert more pressure on the floor.	Unsupported

This example is taken from Teacher A's medium level of ABI implementation.

Similarly, in the "sound" implementation", the concepts of "frequency, wave, amplitude, loudness, intensity" were utilized differently in students' social language. Although the students experienced the buoyancy force and sound in their daily life, there were quite a few differences between their social language and scientific explanation. The Teacher A less frequently allowed the students to be aware of the differences between their social language and scientific point of view. Therefore, the students might not reach sophisticated reasoning in this implementation.

4.3.2. Teacher B

As the Teacher B moved towards a higher level of ABI implementation, the percentage of students reasoning quality relatively increased except the unsupported reasoning as seen in Figure 6. In addition, the percentage of students' questions in both implementation level was the same. The difference among TDMs in both implementation levels might be related with the change in the percentages of students' reasoning qualities.

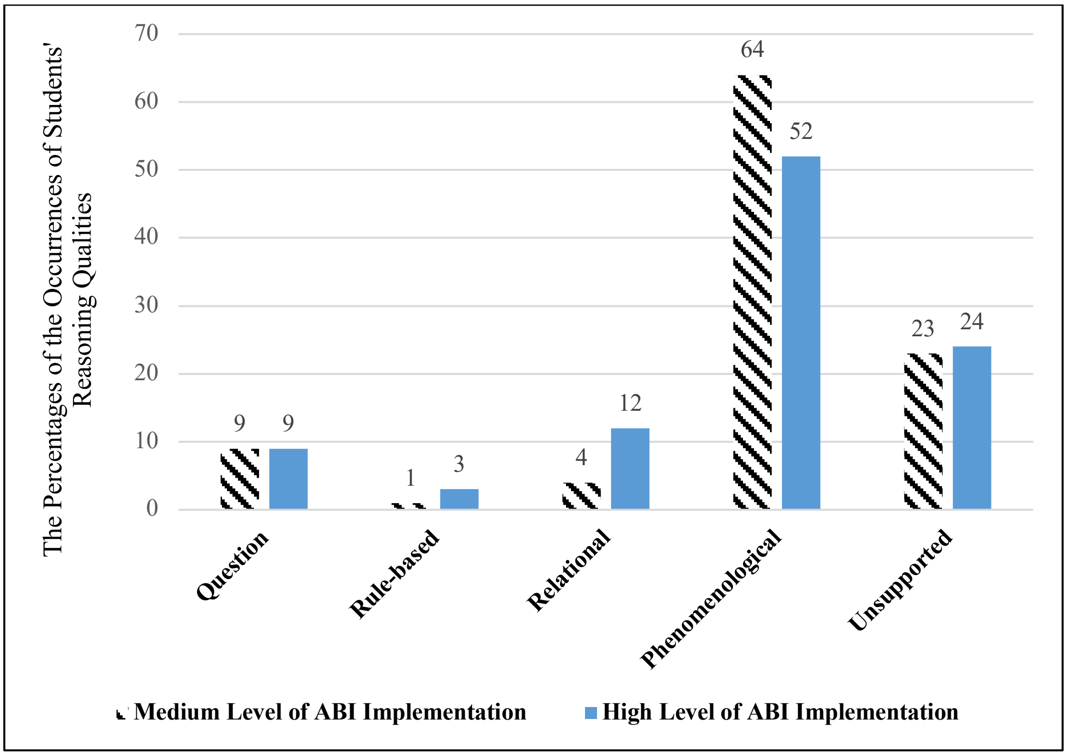

Figure 6. The Percentages of Students' Reasoning Qualities in Teacher B's Medium and High Levels of ABI Implementation

Teacher B enacted knowledge providing and evaluation (4% less) (KPE), communicating (5% less), (COM) less frequently but performs more reflective discourse (6% more) (RED) TDMs in the high implementation level than those in the medium implementation level. There might be a positive relationship between the change in the percentages of KPE and RED moves and the students' reasoning qualities.

In each implementation level, the majority of student reasoning quality was the phenomenological typology (64% in medium level, 52% in high level) and unsupported typology (22% in medium level, 24% in high level). However, as the most sophisticated reasoning, the percentage of rule-based reasoning was the least in the both levels (1% in medium level, 3% in high level). This common trend might be related with RED moves that were less frequently enacted as well as CHAL and SFE moves which were almost never performed in both implementation levels. That might be associated with the less frequency of more sophisticated reasoning qualities.

When the contents of the ABI implementations were examined, in the medium level of ABI implementation, the concepts related with the fertilization were abstract for students. Teacher did not enact enough CHAL, EBR and RED moves in order to reveal students' reasoning and encourage student to support their claim. For example, as seen in Table 21, during turn 245, student explained fertilization by using their daily language of science. After turn 246, teachers can ask evidence of student's claim, challenge with students' idea by asking "How can a baby form when sperm fertilizes the egg?" or ask other students whether they agreed on each other's idea or not.

Table 21. The Example of Students' Reasoning Qualities with the Content "Reproduction, Growth and Development" in Teachers' B Class

Turn	Speaker	Utterance	Student Reasoning Quality
237	S	Well, they're competing, and I'm gonna say something.	Data
238	T	What competes?	No Coding
239	S	A lot of sperms	-
240	T	S/he says many sperms are competing. Then, are they more than one?	No Coding
241	S	Yes	Data
242	T	They are competing. Where do they want to reach?	No Coding
243	S	To reach the egg.	Data
244	T	To reach the egg. What will it be if it becomes the first?	No Coding
245	S	We will be born.	Data
246	T	We will be born.	No Coding

This example is taken from Teacher B's medium level of ABI implementation.

Moreover, in the "electricity" implementation, students were likely to utilize different concepts from their daily language although they were familiar with this content in their daily life. Therefore, students' ideas were mostly decontextualized rather than recontextualized. This might limit students to give more sophisticated reasoning.

4.3.3. The Results of Cross-Case Analysis

For the third research question, the similarities and differences of the relationship between discursive moves enacted by the Teacher A and Teacher B and students' reasoning qualities in the medium and high implementation levels are given below.

In each case, the increase in the percentage of RED and the decrease in the percentage of KPE might be related with the increase in the percentage of students' reasoning qualities in the high implementation level. Therefore, these moves had a potential to trigger the students' reasoning in each case. Moreover, the majority of student reasoning quality was the phenomenological and unsupported, respectively, in both implementation levels of each case. However, as the most sophisticated reasoning, the rule-based typology was the least detected in the both implementation levels of each case. This common trend might have a relevance with RED moves that were enacted less frequently as well as CHAL and SFE moves which were almost never performed in both implementation levels. In each case, only COM moves, the most percentage of TDMs, did not have a potential to increase students reasoning quality. COM moves should be supported with the CHAL, SFE and RED moves in order to increase the students' reasoning quality. However, while students asked more question in the high-level implementation of the Teacher A, the percentage of the students' questioning did not change in high level implementation of the Teacher B. The more change in KPE, RED and COM moves in Teacher A class might encourage students to ask questions in high level of ABI implementation.

The change of teacher moves in different implementation levels reflected students' reasoning quality differently because of various science contents. Although the changing percentages in the KPE and RED discursive moves were greater in Teacher A, the increase in the percentages of relational reasoning in the Teacher B class were more. The reason for this could be due to the different content. Students were more likely to make analogy in "electricity" implementation of the Teacher B. Moreover, the teacher reached a consensus with the students about the relationship between their social language and scientific language. For example, students called "shifting" in their social language rather than "resistance" in scientific language. As given in Table 22, in during turn 127, students gave reasoning supporting by the relationship between the conductivity of matter and electricity. In during turn 557, students made reasoning by backing with the contextualized relationship between shifting matter (resistance) and the brightness of the bulb.

Table 22. The Example of Students' Reasoning Qualities with Content "Electricity" in Teacher B's Class

Turn	Speaker	Utterance	Student Reasoning Quality
127	Student	Fatma teacher, Hakan said that there is something here that prevents the key. Now if we shut down the key, here button, if we turn off the button, the cable enters here, then iron and cable touch each other when we lift the key again lifts up the electricity and does not go from it.	Evidence-based
…….			
552	Teacher	Your friend says that "Did you say the blocking agent in the aluminum foil and in the yarn is equal?"	No Coding
553	Student	No, we didn't say "equal".	Data-based
…….			
556	Teacher	On what basis?	No Coding
557	Student	Slippery materials are less on yarn, more on foil.	Evidence-based

This example is taken from Teacher B's high level of ABI implementation.

CHAPTER 5

DISCUSSION

In this study, the teacher discursive moves, the relationship between students' reasoning quality and teacher discursive moves and communicative approach enacted by the teachers in different implementation levels of ABI were investigated. In this chapter, the findings of the three research questions will be discussed by presenting related literature. This chapter will include implications of this study, limitations and further research.

5.1. Discussion of Findings

5.1.1. Teacher Discursive Moves in Different Implementation Levels

In this study, the differences between the teacher discursive moves in different implementation levels of ABI were investigated. From the perspective of sociocultural learning theory adopted in this study, teacher discursive moves in the social plane (classroom discourse) were linked with students' reasoning qualities. Studies has shown that the use of teacher discursive moves has an impact on the quality and quantity of students' cognitive contribution; such as students' argumentation structure, such as, generating claim, supporting their claims with evidence, defending their claims to peers, persuading others about the validity of their claims (Martin & Hand, 2009), their reasoning quality (Furtak et al., 2010, Soysal & Yilmaz-Tuzun, 2019) and their cognitive pathways (Grimberg & Hand, 2009). Thus, it is important to investigate the factors that vary across the different implementation levels of ABI with respect to the teacher discursive moves, students' reasoning quality and communicative approach enacted by teachers. The finding of this study showed that both of the teachers performed different kinds of discursive moves (KPE, RED, COM, MOF, EMR, SPS,) during the medium and high levels of

ABI implementations. However, the occurrence of frequency and percentage of TDMs varied within (a teacher's medium and high level of ABI implementations) and across the cases (teachers' both levels of ABI implementations). Moreover, SPS, COM and MON moves were dominantly performed by Teacher A and Teacher B in both levels of ABI implementation. A number of studies (Aranda & Tytler, 2015; Mortimer & Scott, 2003; Oh & Campbell, 2013) concludes that various discursive moves, both dialogic and monologic, are necessary for the meaningful learning. In this study, while both teachers performed dialogic TDMs (i.e., asking for evaluation, challenging, prompting for evidence, probing, etc.) and monologic TDMs (i.e., presenting logical exposition, affirming, rejecting, reformulating etc.) during ABI implementation. Only performing dialogic or monologic moves are not enough to address aim of the ABI implementation since teacher should allow students to use not only their alternative thinking and talking system but also scientific thinking and talking system (Soysal, 2007). In more detail, teachers have to use dialogic TDMs to reveal students' alternative thinking and talking system while they have to perform monologic TDMs to allow student to recognize scientific thinking and talking system.

The highest increasing percentages occurred in the KPE, RED and COM moves in different implementation levels of each case although both teachers carried out ABI in different grade levels within different science contents. In terms of KPE moves, the classroom discourse in each case moved beyond traditional triadic pattern by less frequently knowledge proving and evaluation of students' response. Therefore, there was a room where ideas of students are explored in this type of classroom environment (Tytler & Aranda, 2005). This proved the increasing RTOP scoring in the category of student voice through teachers' pedagogical progression toward ABI implementation. On the other hand, IRE pattern does not allow long-termed talk about the idea (Benus et al., 2013). The finding of this study was concurrent with the previous studies (Benus et al., 2013; Pinney, 2014; Tytler & Aranda, 2005) concluding that teachers gave knowledge or evaluative feedback on student response less in high quality classroom discourse. Tytler and Aranda (2005) concluded that experienced teachers went beyond IRE pattern where prevalence of classroom talk was the teachers and students were given little chance to expand their ideas.

Moreover, Benus (2011) found that when teachers' implementation level of ABI increased, the decrease in the occurrence of teacher feedback on student response caused to increase student-student dialogue. Lemke (1999) concludes that in the classroom discourse where the triadic pattern is persuasive, a teacher has the control over the flow of the negotiation as to who contributes in the classroom discourse and which ideas are regarded as legitimate. This study also provided evidence that KPEs moves were related with RTOP categories, student voice, problem solving and reasoning and teacher role. Also, in terms of RED moves, the teachers conducted reflective discourse more frequently in high level of ABI implementation. RED moves were examined as a sub-category of open-ended questions or discursive moves in other studies (Kılıc, 2016; Kim & Hand, 2015; Martin & Hand, 2009). These studies examined the RED moves as an eliciting question (Martin & Hand, 2009, a meta-cognitive question (Kılıç, 2016) and a challenging process that explained whether the student and teacher agreed on each other's idea or not (Kim & Hand, 2015). The common finding of these studies is that when the implementation level of ABI increase, teachers are more likely to encourage students to evaluate each other's ideas and make reflection on their ideas. Moreover, RED moves support a social aspect of argumentation by promoting the students to judge and critique their understanding of science concepts (Berland & Reiser, 2011). Jiménez-Alexander et al. (2000) conclude that teachers' attempt to promote students to explain and persuade each other about the validity of their claim, and this results in argumentation. On the other hand, students are not required to convince their peers in traditional classroom discourse where the transmission and evaluation of knowledge is predominant (Berland & Reiser, 2011). In this respect, these moves increase the interaction among students by participating them in negotiation within small and whole group and promote students to make justification of their claim while persuading friends. From this point of view, it can be concluded that RED moves are associated with the items of all RTOP categories. In terms of COM moves, the greater part of the TDMs included these moves in both implementation levels of each teacher. It showed that the teachers in medium and high levels of ABI implementations were more likely to understand student's idea to make it available on the discussion. This finding is consistent with other study (Soysal & Yilmaz-Tuzun, 2019) reporting that COM moves are significant for revealing meaning and reasoning behind the student response during the ABI implementation. Additionally, although the total percentage of COM moves was the highest changing in a high-level of ABI implementation of each case, different trend of change was observed in each case. When looking into sub-categories of COM moves, the highest changing percentage (10%) was observed in the "reformulating" move during the Teacher A's high level of ABI implementation. O'Connor and Michael (1996) found that teacher reformulated students' utterances in order to clarify them and introduce new scientific concepts to students. In this study, Teacher A reformulated student response more in the high level of ABI implementation because the content "sound" was the abstract for student. This move also enables to make students' understanding apparent on the classroom discourse and shows that their explanation is worth being elaborated on (Kawalkar & Vijapurkar, 2013). In this way, students were more frequently engaged in dialogic interaction as seen in the highest changing RTOP scores of Teacher A in the category of student voice. In this sense, the COM moves, especially "reformulating", contributed to the quantitative increase of student voice as indicated in the findings of Soysal (2019). Moreover, COM moves are related to the items of all RTOP categories. When sub-categories of COM moves were examined, there seemed to be lowest changing moves through pedagogical progression of Teacher B. This study provided little evidence to explain the difference between the percentages of COM moves in different implementation levels of ABI. Further research should be conducted considering the students' prior knowledge that affects teachers' discursive moves.

On the other hand, MOD, EMR, LAN, CHAL, SFE, SPS and MOF were the lowest changing or non-changing discourse moves. Moreover, the first fifth moves were rarely observed in both implementation levels of ABI for each case. The reason for this is discussed below. First, MOD move is utilized to show students how scientists work; for example, how they collect data, conduct measurement, control variables and so on. This move was seldom performed in this study since the teachers needed to act MOD move when students presented their work in front of the class and negotiated each other about their findings. The finding of this study, in that sense, is similar with Soysal's (2018) study. Second, in this study, teachers less frequently needed to perform EMR moves in order to form a comfortable classroom environment for the sake of the classroom management. The changing percentage of these moves was the lowest since students took cognitively and physically an active role in ABI implementation in spite of different degrees. Similar to the finding of this study, Baker, Lang and Lawson (2002) state that effective inquiry-based teaching widely decreases classroom management issues due to high interest and motivation of students. Moreover, in order to provide mutual respect, non-verbal behavior can be also used in a classroom. For example, Kim and Hand (2015) found that the teacher did not circulate around the class in medium level implementation of ABI; rather, the teacher circulated through interacting with students in high implementation of ABI. Third, both teachers did not also require displaying LAN move in both levels since they do not negotiate the concepts at the end of the students' presentation. LAN move are used in order to in order to reach a consensus about the concepts that are emerged from end of the classroom negotiation (Soysal, 2019). The items in RTOP categories are not related with these moves (MOD, EMR, and, LAN).

In both levels of ABI implementation for each case, the teachers had a problem with performing challenging moves. These moves are the way to encourage students to defend their explanations during small and whole group negotiation. SFE move was expected to increase in high levels of ABI implementations because this move was related to the RTOP category of problem solving and reasoning. However, both teachers struggled with improving SFE and CHAL moves in high level of ABI implementation. The reason for this could be inadequate teacher preparation before ABI implementation.

MOF and SPS moves were dominant in both levels of ABI implementation for each case. MOF and SPS are the fundamental moves of ABI. However, the change in the percentage of these moves is the lowest in each teacher's implementation. MOF moves enable students to be aware of what is happening in the classroom discourse (Soysal, 2007). Therefore, these moves help teachers to reach big ideas of ABI implementation. Moreover, SPS moves are essential to reveal students' daily life thinking and talking system during the ABI implementation. MOF and SPS move are not directly related with the items of all RTOP categories. However, these moves are pre-organizer to create a classroom discourse for the expected behaviors in the RTOP scores.

When looking into the teachers' pedagogical development during ABI implementation, this study showed that teachers improved their pedagogical strategies to support argumentation in classroom discourse within longitudinal PD program. However, they still struggled with improving CHAL and EBR moves through their pedagogical progression. This finding is concurrent with earlier study (Boyle, Lamprianou, & Boyle, 2005) showing that even if teachers attend a PD program whose duration is longer, they cannot change all the inadequate practices since such a change is difficult. Moreover, Newton et al. (1999) found that even experience teachers need to be involved in PD more frequently. Similarly, Wilkinson et al. (2017) found that while teachers improved their pedagogical strategies for effective discourse, they had difficulty in posing questions that expand students' idea. Moreover, although RTOP is commonly used to measure reformed based teaching practices, as structed protocols, there are some limitations that classroom dynamic is not deeply analyzed (Millis, 1992).

5.1.2. Communicative Approach in Different Implementation Levels

In each case, teachers utilized more interactive/dialogic and less interactive/ authoritative approach in high level of ABI implementation. This means that teachers considered students' points of views more, while students were encouraged to be involved in dialogue more frequently. While Teacher A did not perform any non-interactive approach in both levels of ABI implementation, The Teacher A only enacted non-interactive/dialogic once in both levels. The finding of this study is aligned with the other studies (Alexander, 2006; Benus et al., 2013) stating state dialogic discourse is the indicator of the effective classroom discourse. On the other hand, Mortimer and Scoot (2003) state that teachers have the ability to use all types of communicative approach to assure a meaningful learning in classroom discourse. Soysal (2017) found that the four types of communicative approach were associated with three phases of ABI implementation. In the Soysal's (2017) study, during initial discussion, teachers used interactive/dialogic and non-interactive/dialogic communicative approach in order to reveal students' idea. Then, during the scientific investigation of students, teachers performed interactive/authoritative. As a final phase, during the whole class discussion, teachers enacted non-interactive/authoritative approach in order to inform students about the scientific knowledge. From this point of view, in this study, when teachers' level of ABI implementation increased, teachers were more likely to decontextualize students' idea. In other words, students' everyday language was dominant rather than scientific language in the high level of ABI implementation. However, there must be tension between authoritative and dialogic discourse (Mortimer & Scott, 2003). In this study, overuse of students' daily language was barrier for student to perform most sophisticated reasoning.

5.1.3. The Relationship between Teacher Discursive Moves and Students' Reasoning Quality in Different Implementation Levels of ABI within the Different Science Contents

This study examined the relationship between the teachers' discursive moves and the students' reasoning qualities in different levels of ABI implementation with different science content. It is valuable to explore how teacher's pedagogical development reflects student's cognitive contribution in different qualities of ABI implementations Based on Vygotsky's sociocultural perspective (1978), teacher scaffolding strategy is important on the social plane (classroom discourse), and thus, affects students' internal thinking (quality of reasoning). During the ABI implementation, students construct scientific knowledge at an individual level by generating their argument and at social level by presenting and defending their claim to their peer and teachers.

In each case of this study, the highest change in KPE and RED moves was related with the improving students' reasoning qualities as the quality of ABI implementations improved. This study provided evidence that when teachers gave information and evaluated students' responses less and displayed reflective moves more, such as throwing and asking for evaluation, students reasoning qualities improved during ABI implementation. This finding is similar with other studies

(Chin 2006; Kim & Hand, 2014; McNeill & Pimentel, 2009; Soysal & Yilmaz-Tuzun, 2019) in that the third move of triadic pattern (IRE) plays a significant role in students' cognitive contribution in the classroom discourse. For instance, when students' responses are accepted as "correct", they do not need to present their claim through justifying by making contextualized relationship or scientific principles. When teachers ask productive follow-up questions rather than evaluating students' answers, students' cognitive contributions increase since they are asked to offer the justification of their claims (Chin, 2007). The finding replicates the finding of other studies concluding that RED moves help students to be engaged in dialogic interaction where students have an effort to convince each other presenting claims with their justification (Blosser, 1973, Chin, 2007; Martin & Hand, 2019; McNeill & Pimentel, 2010; Soysal, 2019; van Zee & Minstrell, 1997b). Moreover, RED moves help students to ask questions to each other (van Zee & Minstrell, 1997a). Students questioning can be a potential tool to trigger the classroom negotiation and encourage students to take account of pro and counter arguments while discussing with peers. Therefore, students are more likely to be aware of their fallacy reasoning and have an effort to support their explanation with various backing (Chin & Osborne, 2008). In case of Teacher A, the change in the percentage of KPE, RED and COM moves allowed student to ask more question to each other and their teachers in high level of ABI implementation. Hence, it can be concluded that the finding of this study is consistent with the sociocultural theory (Vygotsky, 1981) that the improvement of individual thinking is related to the connection between social and individual plane by means of language.

In each case, COM moves which were the dominantly displayed in both levels of ABI implementation contributed to the students' reasoning qualities. However, this contribution was different when we considered the sub-categories of COM moves for each case. The reformulation move, which was the highest increasing percentage in Teacher A's high level of ABI implementation, might lead to increase the interaction between student-student and student and teacher where students had a potential to use more sophisticated reasoning. Although students' reasoning qualities in each case's classroom relatively increased through teachers' pedagogical progression, data and unsupported reasoning typologies were predominant in both implementation levels of ABI for each case. Moreover, students had difficulties in supporting their claims with evidence and scientific principles in this study. Other studies have indicated that students are less likely to explain scientific principles that support students to connect evidence and claim (McNeill & Pimentel, 2009). Moreover, students have difficulty with reasoning by supporting their claim with evidence and what is regarded as evidence even in the high level of ABI implementation (McNeill et al., 2006 and Benus et al., 2013). The inadequacy of CHAL, RED (relatively) and EBR moves limited students' the most sophisticated reasoning in both levels of each case although COM moves were dominantly displayed in both implementation levels. Similarly, Soysal and Yilmaz-Tuzun (2019) indicate that while the function of COM moves is a "pre-organized" to ensure environment for student to show higher reasoning quality, the contribution of RED moves to students reasoning is considerably important. On the other hand, other studies have found that COM moves have a positive impact on students' reasoning quality (Martin & Hand, 2009). Oh and Campbell (2013) also report that CHAL moves have a potential to help students to increase their reasoning quality and their ability of explaining their comprehension by using scientific knowledge.

In this study, the relationship between students' cognitive contribution and teachers moves was examined within different contents in the different levels of ABI implementation. The science content is a factor that determines the process of reasoning in argumentation discourse (McNeill et al., 2006; Sadler, 2006). In this study, students' reasoning qualities were associated with the learning demand and abstract of scientific concepts. The purpose of the teaching science is to introduce social language of school science to students (Leach & Scott, 2002). To this end, teachers should not only use students' daily language of science but also persuade them to use scientific knowledge and follow their comprehension of science (Mortimer & Scott, 2003). There is a conflict between students' social language and scientific explanations. Mortimer and Machado (1999) maintain that effective teachers' pedagogical strategies are related to both their discursive moves and planning of activities to overcome this cognitive conflict. McMahon (2012) makes suggestions about teacher discursive moves that teachers should challenge students' ideas to make a relationship between student's daily life observation and scientific explanation. Chin (2006) also concludes that CHAL move triggers students to make a reflection on scientifically inaccurate responses, their thinking processes and to explore their fallacy reasoning. Therefore, challenging moves have a great potential to increase students' sophisticated reasoning (Soysal & Yilmaz-Tuzun, 2009) and facilitate to introduce the school language of science. Leach and Scott (2002) offer suggestions for planning sequences of lesson for a meaningful learning. In this sense, teachers should be aware of the difference between students' daily language of science and social language of school science to improve the teaching sequence. With respect to this study, teachers did not successfully overcome the learning demands of science concepts because of inadequate EBR, CHAL and RED (relatively) moves. That is why students could not reach the most sophisticated reasoning in both levels of ABI implementation.

5.2. Limitations

One of the limitations of this study was that analyzing classroom discourse was limited with the whole class discussion during ABI implementation. However, small group discussions, one of the parts of the ABI implementation, are also important to identify the discursive moves, communicative approach performed by teachers and the relationship between student's cognitive contribution and students' discursive moves. In this study, the videos of small group discussion were not recorded because of technical problems. Second limitation of this study was arisen from the purpose of the study which was to deeply understand two teachers' classroom discourse in the medium and high levels of ABI implementation. Since there were limited participants, findings will not be generalized to other cases. Third limitation of this study was that students in individual cases were different grade levels and had different levels of prior knowledge. The last limitation of this study was that there were not field notes and interviews with teachers and students. The data could be supported with different data sources for in-depth understanding of the classroom discourse.

5.3. Implication of the Study

The findings of this study are discussed with the current literature above. The implications of this study are given for teachers and PD program. First, through investigating TMDs, communicative approach and the relationship between TDMs and students' reasoning quality in medium and high levels of ABI implementation, the factors that differentiate across the different implementation levels were determined. In this sense, the trainers of PD programs can take into account these factors in order to prepare content of in-service training. Second, for the meaning making in science classroom, both dialogic and authoritative discourse are essential depending on teaching purpose. This issue can be discussed with teachers by means of video-recording of ABI implementation during PD program. In this way, teachers will be aware of that only dialogic or authoritative approach do not provide effective discourse. Thirdly, Martin and Hand (2009) state that teacher needs at least 18 months to change their pedagogical practice Although teachers improved some TDMs within PD program in this study, they still had difficulty in displaying CHAL, SFE and RED moves that were significant for the increasing students' reasoning qualities. Teachers should be encouraged to implemented ABI more frequently in their classroom during the PD program. Moreover, teachers may need more time and practice for the significant pedagogical change. Fourthly, during the PD program, it can be emphasized that teachers should prepare their lesson plan by considering learning demand of the science content. Moreover, it is also showed that how learning demands influences students' thinking and talking system. Finally, teachers do not have awareness about the impact of their discursive moves on students' quantitative and qualitative cognitive contributions (Oliveira 2010; Soysal, 2018). During the longitudinal PD program, the relationship between TDMs and students' cognitive contribution will be examined with teachers as in this study. This might allow them to make self-reflection on their pedagogy, in turn, increase their awareness about the classroom discourse. Moreover, teachers can be given on-going support to improve their TDMs for the effective classroom discourse within PD program.

5.4. Recommendation for Future Research

Recommendations for future research are presented as follows;

- As limitation of this study, further studies will be conducted with teachers who have a low level of ABI as well as various RTOP scoring range in the same level of ABI implementation.
- Similar study will be conducted in different grade levels with different science context.
- The relationship between reasoning quality of students' questions and teacher discursive moves can be deeply investigated.
- The statistical analysis can be conducted in order to examine the relationship between teacher discursive moves and students' reasoning quality in different implementation levels.
- It can be crucial to investigate the relationship between students' reasoning quality and TDMs as well as communicative approach enacted by teachers in different parts of ABI implementation (for example, initial negotiation, group discussion and students' presentation).
- In order to generalize the findings of this study, more teachers will be included in future research.

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APPENDICES

APPENDIX A. ELEMENTS OF REASONING IN SCIENCE CLASSROOM DISCOURSE

Elements of Storyline	Elements of Reasoning (General)	Elements of Reasoning (Specific)	Definition
Premise	Premise	Premise	A statement describing the relevant characteristics or properties of the object about which the Claim is made (i.e., the conditions for the claim). The Premise is the "given" information from whence the Claim is derived upon. Includes: object, state of an object, general expression ("subject of reasoning"), point of reference
Claim	Claim	Claim	A claim about a specific premise. This includes either what something will do in the future (prediction/ presumption), or is happening in the present or past (conclusion or outcome). A claim could be expressed as a relationship among datapoints (evidence), statements about single datapoints (data), and statements of generalized relationships (rules); however, it is an ***isolated*** statement that is not used as backing.
	Backing	Data	A supporting statement (backing) describing the outcome of a single specific experiment or a single observation in a personal anecdote or prior knowledge / books / tests ***in support of a claim***.
		Evidence	A supporting statement (backing) summarizing a related set of Data ***in support of a claim.*** Evidence is specific to the context in which the Data were collected. It describes a **contextualized relationship** between two properties, a property and a consequence of that property, or a finding, rather than a general principle or law.
		Rule	A supporting statement (backing) describing a **generalized relationship**, principle, or law ***in support of a claim.*** This relationship is general in the sense that it is expected to hold even in contexts and circumstances not previously observed.

Note. Reprinted from "A Framework for Analyzing Evidence-Based Reasoning in Science Classroom Discourse" by Furtak, E. M., Hardy, I., Beinbrech, C., Shavelson, R. J. & Shemwell, J. T. 2010, *Educational Assessment, (15)*, 3-4, 175-196.

APPENDIX B. THE OBSERVED TEACHER DISCURSIVE MOVES WITH THE DESCRIPTION AND EXAMPLES

1. The Category of Knowledge Providing & Evaluating (KPE) Discursive Moves

In KPE discursive moves, teachers provide knowledge to students by presenting logical expositions, verbal cloze and asking for recalling. Additionally, they evaluate students' response by either accepting or rejecting (Soysal, 2017). As seen in Table 1, the teacher provided students with canonical knowledge of science during 208 by presenting a consistent idea or an argument. He affirmed students' response by presenting logical exposition during turn 212.

Table 1. The Example of the Discursive Moves Including Sub-Categories of KPE

Turn	Speaker	Utterance	Discursive Move
208	T	Let us briefly show with the symbol. We say F or K, it doesn't matter. So, what's it pulling down?	Presenting logical exposition//Asking for making prediction
209	S	Gravity Force	No Coding
210	T	Well, remember from yesterday, it's gravity. // If gravity on the surface affects a mass, which property of that object would be revealed? What properties of an object would be revealed by the force of gravity acting on an object?	Monitoring (retrospective)//Asking for recalling
211	S	Gravity Force	No Coding
212	T	Okay, // gravity is pulling this object down. We said that the gravity on world is different in different months.	Accepting//Logical exposition//Asking for recalling

This example is taken from Teacher A's medium level of ABI implementation.

2. The Category of Science Process Skills (SPS)

In these TDMs, teachers request students to show SPS such as, observing, predicting, comparing and inferencing through the ABI implementation (Soysal, 2017). The example is listed in Table 2. During the turn 50, the teacher asked students to compare sound waves to other waves. Then, students were asked to make a prediction about other students' responses. All of these discursive moves are the follow-up questions to the students' previous responses.

Table 2. The Example of the TDMs including asking for observing, predicting, comparing and inferencing

Turn	Speaker	Utterance	Discursive Move
50	T	Sound spreads in waves. When you say wave, what waves do you associate with?	Accepting// Asking for simple comparison
51	S	Sea waves.	No Coding
52	T	Well sea waves. Is the wave still in the sea?	Accepting/Asking for making prediction
53	S	No, something has happened as a result of interaction with the wind.	No Coding
54	T	Can wave occur without the wind?	Asking for simple comparison
55	S	Students: yes	

This example is taken from Teacher A's high level of ABI implementation.

3. The Category of Communicating (COM) Discursive Moves

Communicating (COM) discursive moves include subcategories as follows; probing, asking for an alternative response, requesting for clarification, reformulating, passive re-voicing, and embodying. The aim of this discursive moves in this category is to understand the underlying meaning of students' utterance and to make students' utterance more understandable and accessible to students. In other words, communicating discursive moves provide an opportunity for students and teachers to understand and communicate with each other (Soysal, 2017). The example is given in Table 3. The teacher prompted students to expand her/his response by asking the question during turn 11. After getting a response from the student, the teacher requested student to clarify the meaning of "downward" during turn 15. The teacher provided students with a concrete example for their understanding of the direction of gravity during turn 17. After that, the student's response was transformed into a more understandable and accessible form for students during turn 19.

Table 3. The Example of the Discursive Moves Including Sub-Categories of Communicating

Turn	Speaker	Utterance	Discursive Moves
11	T	Well // does the weight has any direction? Is there a direction of the weight on world?	Accepting//Probing
12	S	No, it exists, Yes, it exists	No Coding
13	T	Wait for your turn.	Ensuring mutual respect
14	S	Teacher,yes it is, the direction is down.	
15	T	Is it down to the ground?	Requesting for clarification
16	S	To gravity	No Coding
17	T	So when I release that coin	Embodying
18	S	Yes to the ground	No Coding
19	T	Yes, it has a direction	Reformulating

This example is taken from Teacher A's high level of ABI implementation.

4. The Category of Monitoring and Framing (MOF) Discursive Moves

The sub-categories of MOF discursive moves are monitoring, focusing and summarizing. In the monitoring role, the teacher encourages students to monitor the discourse in the classroom. This monitoring move can occur in three ways; on-moment monitoring, retrospective monitoring and prospective monitoring. In the focusing role, the teacher gets students' attention to the students' utterance or to the significant aspect of the dialogue through ABI implementation. Additionally, in the summarizing role, teacher summarizes the ideas that are discussed earlier (Soysal, 2017). As seen in the Table 4 the teacher performed the prospective monitoring move by explaining that the "topic of male and female voices" will be discussed later (turn 29). At the same time, he promoted students to monitor what was happening in the classroom. He marked students' responses in order to focus their attention to it (turn 365).

Table 4. The Example of Discursive Moves Including Sub-Categories of Monitoring and Framing

Turn	Speaker	Utterance	Discursive Moves.
29	T	Let's put that question aside. It's a question arousing curiosity, doesn't it? Why are men voice thicker than women voice?, Do not forget it. // Let's go on, we said that in inanimate beings, it could sound like this.	Monitoring (prospective)//Monitoring (on moment)
	………………….		
363	S	Decreased.	No Coding
364	S	But they did not decrease by the same rate.	No Coding
365	T	See your friend who says the same rate is not. Well, which one decreased more?	Focusing//probing

This example is taken from Teacher A's and Teacher B's high level of ABI implementation.

5. The Category of Reflective Discourse Discursive Moves

The reflective discourse has two sub-categories; asking for evaluation and throwing. The teacher can ask the student to evaluate in different ways, asking them to comment on other students' ideas (student-led), teachers' ideas (teacher-led) and cases(case-led). Moreover, the throwing is the discursive move where the teacher gives the responsibility of learning and thinking to students (Soysal, 2017). The example is given in Table 5. During turn 326, he asked students to evaluate the case presented by teachers, whereas students were requested to evaluate the specific students' response during turn 406.

Table 5. The Example of the Discursive Moves Including Sub-Categories of Reflective Discourse

Turn	Speaker	Utterance	Discursive Moves.
326	T	Unpeeled lemon's volume is larger, peeled one's is smaller. // Well, when we look at a peeled lemon, we say that the volume of the unpeeled lemon is larger than the volume of the peeled. The volume causes the lemon to sink in one and the volume in the other causes the lemon to float // Well, is it because of volume?	Reformulating//Summarizing//Asking for evaluation (case-based)
337	S	No, Yes, it is only volume.	No Coding
405	S	The rate of propagation of the sound depends on the type of matter.	No Coding
406	T	The rate of propagation of the sound depends on the type of matter. Is it possible?	Passive re-voicing//Asking for evaluation (student-led)
407	S	Teacher, the only missing thing here is the amount of matter.	No Coding

This example is taken from Teacher A's high level of ABI implementation.

6. The Category of Challenging (CHAL) Discursive Moves

Teachers can challenge with students' ideas in two different ways; challenging by playing devil's advocate role and challenging by monitoring. They present counter argument and contradictions by playing the devil's advocate. Additionally, they present conflicting ideas that are negotiated earlier in the classroom discourse (challenging by monitoring) (Soysal, 2017). The example is given in Table 6.

During the 48 turn, the teacher challenged the students presenting a conflictive view that objects made of the same material can sink and swim.

Table 6. The Example of the Discursive Moves Including Challenging

Turn	Speaker	Utterance	Discursive Moves.
48	T	So when we throw a coin into the liquid, when it sinks, it is again made of iron, and this is a metal, and a ship made of metal is floating on the surface of water. // You throw a coin which is made of metal, it sinks into the water, you throw the ship, it does not sink. // Why would you say that? A coin made of metal, you throw it into the water, a big ship does not sink. Why is that? You put it on it, I wonder why? // Ali?	Challenging (devils' advocate)//Embodying//Asking for evaluation (case-based)
49	S	Water has a buoyant force	No Coding
50	S	Why doesn't it affect the metal?	No Coding

This example is taken from Teacher A's medium level of ABI implementation.

7. The Category of Seeking for Evidence (SFE) Discursive Move

In this TDMs, teachers encourage students to make a claim based on evidence by Prompting evidence-based reasoning (Soysal, 2017). The example is given in Table 7. During turn 255, the teacher requested students to support their claim with evidence.

Table 7. The Example of the Discursive Moves Including Seeking for Evidence

Turn	Speaker	Utterance	Discursive Moves.
255	T	So was your question and claim like this?. So did you verify your claim?	Prompting for EBR
256	S	Yes teacher, So we have verified in our experiments. We have verified our experiment.	No Coding

This example is taken from Teacher A's high level of ABI implementation.

8. The Category of Modelling Discursive Move

In the modelling discursive moves, teachers model how scientists form research questions, collects data to answer research questions, control the variables in the experiment and so on. Overall, in these roles, teachers model the characteristics of the processes of science. These discursive moves are necessary for the ABI implementations since students are expected to carry out the experiments to address their research questions. Thus, students are involved in forming research questions, collecting data, making claims based on evidence (Soysal, 2017). As given in Table 8, during turn 18, he modeled how a scientist formed measurable research question.

Table 8. The Example of the Discursive Moves Including Modelling

Turn	Speaker	Utterance	Discursive Moves.
185	T	Well, then we wrote our question here. // We can fix our question to be measurable	Monitoring (on-moment) /Models
186	S	So how can we change the sound from thin to thick?	No Coding

This example is taken from Teacher B's medium level of ABI implementation.

9. The Category of Labelling and Naming (LAN) Discursive Moves

In the LAN discursive moves, teachers request students to assign labels on concepts (Soysal, 2017). The example is given in Table 9. During 206 turn, he asked students to label the concept they discussed.

Table 9. The Example of Teacher A Discursive Moves Including Labelling and Naming

Turn	Speaker	Utterance	Discursive Moves.
206	T	So, how can we call it?	Asking for assigning labels
207	S	Buoyant force	No Coding

This example is taken from Teacher A's medium level of ABI implementation

10. The Category of Ensuring Mutual Respect (EMR)

The EMR discursive move has an important role in creating comfortable environment for ABI implementation (Soysal, 2017). The example is given in Table 10. During turns 551 and 423, the teacher acted to provide classroom management for the negotiation of the ideas.

Table 10. The Example of the Discursive Moves Including Ensuring Mutual Respect

Turn	Speaker	Utterance	Discursive Moves
100	T	Stop, let's listen to the description, do not interrupt.	Ensuring mutual respect
………………………..			
422	S	Student: Teacher can we ask questions?	No Coding
423	T	Teacher: No, after completion, you can.	Ensuring mutual respect

This example is taken from Teacher B's medium level of ABI implementation.

APPENDIX C. TURKISH SUMMARY / TÜRKÇE ÖZET

Araştırma sorgulamaya dayalı fen eğitiminin gereklilikleri göz önünde bulundurulduğunda, araştırma ve deney yapmalarının ötesinde, öğrencilerin iddialarını oluşturdukları, bu iddialarını delillerle destekledikleri, akranlarının iddialarına karşı argüman sunup onların da fikirlerini değerlendirdikleri sınıf söyleminde öğrencilerin aktif katılımının önemine vurgu yapan pek çok çalışma vardır (Driver, Newton ve Osborne, 2000; Lehrer ve Schauble, 2006). Etkili sınıf söylemi, öğrencilerin akranları ve öğretmenleriyle etkileşimde bulunmalarına olanak sağlamasına ek olarak, aynı zamanda, onların kavramsal öğrenmelerini de destekler. (Candela, 2005; Chin 2007, Molinari ve Mameli, 2013). Geleneksel sınıf söylemlerinde çoğunlukla öğretmenin soru sorduğu, öğrencilerin cevapladığı, öğretmenin öğrenci cevabını doğru veya yanlış olarak değerlendirdiği üçlü diyalog formatı olan IRE (başlangıç-yanıt-değerlendirme) hakimdir. Bu tür bir diyalogun hâkim olduğu sınıflarda öğrenciler arası etkileşim azdır (Macbeth, 2003; Mehan, 1979) ve öğretmen konuşması daha baskındır (Alexander, 2005; Crawford, 2005; Mercer, Dawes ve Staarman, 2009). Araştırma sorgulamaya dayalı öğrenme ortamları ise öğrenci katılımını destekleyen diyalogları kapsamaktadır (McNeil ve Pimentel, 2010). Literatürde, öğretmenin etkili sınıf söylemini sağlamadaki rolünün araştırılması, giderek daha fazla yer almaktadır (Smart ve Marshall, 2013).

Scott (1998), sınıf söylemini, öğretmen, öğrenci ve sınıf söyleminin özelliklerini göz önünde tutarak, otoriter ve diyalojik olarak sınıflandırmıştır. Otoriter sınıf söyleminde, öğretmenler bilgi aktarmaya ve tek bir bakış açısına odaklanma eğilimindedir. Bu bağlamda, otoriter söylemsel hamleler, daha önce tartışılan fikirleri özetleme (van Booven, 2015), öğrencilerin fikirlerini reddederek veya kabul ederek değerlendirme (McMahon, 2012), doğrudan bilgi verme (Scott, 1998), öğretmenin kafasında tek bir doğru cevabı olan ve bu cevap etrafında şekillenen sorular sorma (Mortimer ve Scott, 2003; Scott, 1998) ve öğrencilerin cümlelerini tamamlamalarına izin vermeden cevaplarını kesme (Chin, 2006) olabilir. Diyalojik sınıf söyleminde ise öğretmenler, öğrencilerin fikirlerini derinleştiren sorular sorarak farklı görüşleri keşfetmeleri için fırsatlar sunar. Bu bağlamda, öğrencilerden cevaplarını netleştirmelerini isteme, fikirlerini derinleştirmelerini isteme, dikkatlerini sınıftaki bir söyleme odaklama, dersi takip etmelerini isteme, öğrencilerin kendi öğrenme sürecinin sorumluluğunu almalarına izin verme (van Zee ve Minstrell, 1997b), öğrencilerin karşı argüman geliştirmelerini sağlama ve öğrencilerin fikirlerini temellendirmelerini isteme (Simon, Erduran ve Osborne, 2006) diyalojik söylemsel hamlelere örnektir. Wertsch ve Toma (1991), "sınıf söyleminde işe koşulan soysal düzlemin işleyişin sonraki bireysel düzlemin işleyişine yansıyacağını" belirtmiştir (s. 171). Bu bağlamda, sınıf söyleminin özelliği, öğrencinin bireysel düzlemdeki düşünme sürecinin kalitesini etkilemektedir. Sınıf söylemi alanındaki bazı çalışmalar, otoriter söylem yerine diyalojik söylemin öğrenci merkezli yaklaşımı desteklemede önemli rol oynadığının altını çizmektedir (Alexander, 2006; Chin, 2006, 2007; Martin ve Hand, 2009). Öte yandan, diğer çalışmalar, dersin amacına bağlı olarak, otoriter ve diyalojik yaklaşımın kullanımı arasında bir denge olması gerektiğini göstermiştir (Aguiar, Mortimer ve Scott, 2010; Mortimer ve Scott, 2003). Başka bir deyişle, sınıfta bilimsel kavramların anlamlı öğrenilmesi için hem otoriter hem de diyalojik söylem yaklaşımlarının kullanılması gereklidir çünkü otoriter söylem "kültürel olarak değerli içeriğin güvenilir aktarımı ve sürekliliğini sağlar" iken, diyalojik söylem ise "yaratıcılığı teşvik eder ve yeniliğe izin verir" (Sedova, Sedlacek ve Svaricek, 2016, s. 15). Bu çalışmada hem diyalojik hem otoriter söylemsel hamleler, Araştırma Sorgulama Tabanlı Öğretim (ATBÖ) yaklaşımı bağlamında incelenmiştir.

Araştırmalar, öğretmenin söylemsel hamleleri ile öğrencilerin bilişsel katkıları arasında bir ilişki olduğunu göstermiştir. Sınıf söylemi araştırmaları alanında, öğrencilerin bilişsel katkıları hem nicel hem de nitel yöntemler ile araştırılmıştır. Öğrenci cevaplarının uzunluğu ve öğrenci konuşmasının sınıf söylemi içindeki oranı üzerinden öğrencilerin nicel katkısı araştırılmıştır (Soysal ve Yılmaz-Tüzün, 2019). Ayrıca, öğrencilerin bilişsel katkılarının niteliği, bilişsel beceriler, argümanın yapısı ve akıl yürütme kalitesi açısından incelenmiştir. Önceki çalışmalar çoğunlukla öğretmen sorularının öğrencilerin bilişsel katkıları üzerindeki etkilerini araştırmıştır (Soysal ve Yılmaz-Tüzün, 2019). Araştırmalar (ör. Erdoğan ve Campbell, 2008;

Smart ve Marshall, 2013; van Zee ve Minstrell, 1997b) açık uçlu soruların doğrudan öğrencilerin bilişsel katkısı ile ilgili olduğunu göstermiştir. Örneğin, Martin ve Hand (2009) ile McNeill ve Pimentel (2010), öğrencilerin sorgulama stratejileri ile sundukları argümanların yapıları arasında bir ilişki olduğunu belirtmişlerdir. Ayrıca sınıf söyleminde kullanılan açık uçlu öğretmen sorularının, öğrencilerin, öğretmenleri ve akranlarıyla etkileşime girmesi olarak tanımlanan öğrenci sesini artırdığı sonucuna varmışlardır. Öğrencinin sesi sınıf söyleminde arttıkça iddiada bulunma, iddialarına güçlü deliller sunma gibi argüman yapısının kalitesinin göstergeleri de artmaktadır (Martin ve Hand, 2009; Mercer, Dawes, Wegerif ve Sam 2004; Naylor, Keogh ve Downing, 2007). Durum böyle olunca, öğrencilerin katkısındaki (öğrenci sesi) nicel artış, onların bilişsel katkısının (argüman yapısı) da niteliksel olarak artmasına neden olabilmektedir (Soysal, 2017). Öte yandan, Boyd ve Rubin (2006), öğrencilerin cevaplarını derinleştiren yapışık soruların, soruların yapısından ziyade (açık uçlu ve kapalı uçlu sorular), öğrencilerin bilişsel becerilerini artırdığını önermektedirler. Başka bir deyişle, tüm açık uçlu sorular, öğrencilerin bilişsel süreçlerini desteklememekte ve tüm kapalı uçlu sorular da öğrencilerin bilişsel katkısını sınırlamamaktadır.

Argümantasyon hem bireysel hem de sosyal düzeyde gerçekleşmektedir (Jimenez-Aleixandre ve Erduran, 2008; McNeill ve Pimentel, 2010). Bireysel düzeyde, bireyler iddialarını akıl yürütme yoluyla delillere dayandırarak yapılandırırlar (Driver vd., 2000; McNeill, 2009). Fakat sosyal düzeyde gerçekleşen argümantasyon, bireylerin birbirlerinin iddialarını ve kanıtlarını sorguladıkları; birbirlerini, iddialarının geçerliliği konusunda ikna etmek için çaba gösterdikleri sosyal etkileşimi içerir (Berland ve Reiser, 2011). Bu açıdan bakıldığında hem bireysel hem de sosyal düzeydeki argümantasyon sınıf söyleminde gereklidir çünkü argüman, bireysel düzeyde yapılandırılır ve sonrasında anlam, sosyal düzeyde müzakere edilir. Öğretmen pratiğinin argümantasyon söylemine doğru kayması yalnızca öğrencilerin sesinin baskın olduğu değil, aynı zamanda onlara müzakere etme fırsatı verilen bir öğrenme ortamı yaratmaya yönelik olarak sınıf söylemini de değiştirmeyi gerektirir (Crawford, 2000). Argümantasyonun fen sınıflarında yer alması gerektiği göz önüne alındığında, argümantasyonun sınıflara entegrasyonu için farklı öğretim ve öğrenme teknikleri geliştirilmiştir (Cavagnetto, 2010; Yun ve

Kim, 2015). Bu çalışmada, üç farklı argümantasyon temelli yaklaşımdan gömülü yaklaşım seçilmiştir. Gömülü yaklaşımlardan biri olan ATBÖ, öğrencilere bilginin yapılandırılması için gerekçelerini müzakere etmelerine ve akıl yürütmeleri üzerine yansıtıcı düşünmelerine fırsat veren dil temelli bir argüman yaklaşımıdır (Driver vd., 1994, 2000; NRC, 1996). Bu yaklaşım, öğrencilerin sözlü ve yazılı argümanları kullanarak kavramsal öğrenmelerini geliştirmelerine yardımcı olur (Hand ve Keys, 1999).

Öğretmenin pedagojik stratejileri, ATBÖ uygulamasının kalitesi veya düzeyi ile ilişkilidir (Benus, Yarker, El ve Norton-Meier, 2013; Kılıç 2016; Omar ve El, 2004; Yeşildağ-Hasançebi ve Kıngır, 2012). Bu çalışma kapsamında öğretmenlerin RTOP puanları, orta ve yüksek düzeyde ATBÖ uygulama yaklaşımı olarak sınıflandırılmıştır. Bununla birlikte, öğretmen gözlem protokolü (Reformed Based Observation Protocol, RTOP) skoru aslında ATBÖ uygulamasının kalitesiyle ilgili olsa da (Cavagnetto vd., 2010; Martin ve Hand, 2009), farklı uygulama seviyeleri arasında farklılık gösteren faktörler yakından incelenmeli ve tanımlanmalıdır (Benus vd., 2013). Öğretmenlerin, fen bilimleri dersinde ATBÖ uygulamalarını daha yüksek uygulama seviyesine doğru nasıl ilerlettiklerini görmek için, öğretmenlerin söylemsel hamlelerinin detaylı bir şekilde karşılaştırılarak araştırılmasına ihtiyaç vardır (Kim ve Hand, 2015; Pinney, 2014). Bu karşılaştırma, aynı zamanda uygulama kalitesi arttıkça sınıf söylemenin nasıl değiştiğine de ışık tutacaktır.

Çalışmalar (örneğin, Kazemi ve Hubbard 2008), anlamlı öğrenme sürecinde sınıf söylemini geliştirmek için öğretmenlerin mesleki gelişim programına ihtiyaç duyduklarını ileri sürmektedir. Ek olarak, mesleki gelişim programlarının özelliği, öğretmenlerin pedagojik değişiklikleri için önemli bir faktördür. Ayrıca, literatürde kısa süreli mesleki gelişim programında öğretmenlerin pedagojik ilerlemesi incelenmiştir (Benus vd., 2013). Etkili mesleki gelişim programının sınırlı ve süreli bir şekilde değil daha çok bir süreç olarak ele alınması gerektiği görülmektedir (Loucks-Horsley ve diğerleri, 1987, 1998). Dahası, öğretmen pedagojisinin ilerleyişi sürekli ve tekrarlı bir çaba olarak görülür (McLaughlin ve Marsh, 1978).

Bu bağlamda, öğretmenlerin pedagojik gelişimini boylamsal ve sürekli bir mesleki gelişim programı kapsamında araştırmak gerekmektedir.

Bu çalışma, ATBÖ yaklaşımı bağlamında yürütülen bir mesleki gelişim programı kapsamında gerçekleştirilmiştir. Çalışmanın temel amacı, fen bilimleri öğretmenlerinin orta ve yüksek düzey ATBÖ uygulamalarında sınıf söylemini ve öğrencilerin akıl yürütmelerini incelemektir. Çalışmanın amacı doğrultusunda, farklı düzey ATBÖ uygulamalarında öğretmenlerin sergiledikleri söylemsel hamleler incelenmiştir. Bununla birlikte, öğretmenlerin orta ve yüksek düzey uygulamalarda kullandıkları iletişimsel yaklaşımlar araştırılmıştır. Son olarak, çalışmada, öğretmenlerin söylemsel hamleleri ve öğrencilerin akıl yürütme kalitesi arasındaki ilişkinin farklı fen konuları bağlamında incelenmesi hedeflenmiştir. Çalışmada aşağıdaki soruları ele alınmıştır:

1. Orta ve yüksek ATBÖ uygulamasında öğretmenler tarafından gerçekleştirilen söylemsel hamleler nelerdir?
2. Orta ve yüksek ATBÖ uygulamasında öğretmenler tarafından gerçekleştirilen iletişimsel yaklaşımlar nelerdir?
3. Farklı fen konuları bağlamında, orta ve yüksek ATBÖ uygulamasında öğretmenlerin söylemsel hamleleri ve öğrencilerin akıl yürütme kaliteleri arasındaki ilişki nedir?

Bu çalışmada, araştırma sorularını cevaplamak için bir nitel araştırma yaklaşımı olan durum çalışması araştırma tasarımı kullanılmış bu da araştırmacının, iki öğretmenin orta ve üst düzey ATBÖ uygulamalarında sınıf söylemini derinlemesine anlamasını sağlamıştır. Çalışmada, araştırma sorusu ile ilgili çeşitli perspektifleri temsil etmek amacıyla birden çok durum ele alınması gerektiğinden, durum çalışmasının bir çeşidi olan çoklu durum çalışması kullanılmıştır (Creswell ve Poth, 2018). Çoklu durum çalışması, araştırmacılara durumların kendi içinde ve aralarındaki farklılıkları veya benzerlikleri belirleme olanağı sağlamaktadır (Yin, 2003). Bu sebeple, iki durumun bulguları arasındaki farklılıkları ve benzerlikleri araştırmak için karşılaştırmalı durum analizi yapılmıştır.

Çalışmadaki katılımcı iki öğretmen, TUBİTAK tarafından desteklenen "Argümantasyon Tabanlı Bilim Öğrenme Yaklaşımının Hizmetiçi Eğitim Programları Yoluyla İlköğretim Seviyesindeki Öğretmen Pedagojisi Üzerine ve Öğrenci Akademik Başarı, Beceri ve Tutumlarına Olan Etkisinin Araştırılması Projesi" kapsamında, mesleki gelişim programına katılan öğretmenler arasından amaçlı örneklem yöntemiyle seçilmiştir. Amaçlı seçim kriteri öğretmenlerin ATBÖ yaklaşımını uygulama seviyesidir. Öğretmenlerin kimliğini saklı tutmak amacıyla bu çalışmada Öğretmen A ve Öğretmen B olarak isimlendirilmişlerdir.

Mesleki gelişim programı üç temel bileşenden oluşmaktadır: 1) Hizmet içi eğitimler 2) Sürekli destek 3) Ölçme ve değerlendirme faaliyetleri. Öğretmenler, her biri beş gün süren beş hizmet içi eğitime katılmışlardır. Her bir hizmet içi eğitim, ATBÖ yaklaşımı için önemli temalara odaklanmaktadır. Bu temalar; ATBÖ yaklaşımının tanıtılması, soru sormanın önemi, ATBÖ sınıf uygulamasının değerlendirilmesi, öğretmenlerin pedagojik uygulamalarındaki değişimin ve sınıf deneyiminin paylaşılması ve öğretmen müzakere döngüsüdür. Her hizmet içi eğitimin belirli bir teması olmasına rağmen, eğitim programlarında üç temel unsur bulunmaktadır. İlk olarak, her bir eğitim, öğretmenlerin öğrenme ve öğretme konusundaki inançlarını ve algılarını sorgulamalarına fırsat vermiştir. İkinci olarak, öğretmenler, ATBÖ yaklaşımını öğrenen olarak tecrübe etmişlerdir. Bu bağlamda, öğretmenlerin kendi öğrenme süreçlerine yansıtıcı bakmaları sağlanmıştır. Son olarak öğretmenler, bir sonraki akademik dönemde ATBÖ yaklaşımını sınıflarında uygulamak için ünite hazırlığı yapmışlardır. Mesleki gelişim programı kapsamında, projeye katılan öğretmenlere sürekli destek (çevrimiçi ve yerinde destek) verilmiş; sınıf uygulamaları hakkında geri bildirimde bulunarak öğretmenlerin ATBÖ uygulamalarını geliştirmelerine fırsat verilmiştir. ATBÖ uygulaması üç bölümden oluşmaktadır; giriş tartışması, öğrenci araştırmaları ve büyük grup tartışması. Bu çalışmadaki öğretmenler, farklı fen konularında ATBÖ uygulamalarını gerçekleştirmişlerdir.

Öğretmenlerin dahil oldukları proje kapsamındaki ATBÖ uygulamalarının düzeyleri, "matematik ve fen alanındaki reform uygulamalarını" ölçmek için bir araç olan Öğretmen Gözlem Protokolü (Reformed Based Observation Protocol, RTOP) (Sawada vd., 2002) aracılığıyla belirlenmiştir. Ardından, Martin ve Hand (2009), ATBÖ yaklaşımının bileşenleri ile orijinal RTOP'un maddeleri arasındaki uyumu sağlayarak RTOP'u modifiye etmiştir. 13 maddelik RTOP; öğrenci sesi (5 madde), öğretmen rolü (2 madde), problem çözme ve akıl yürütme (5 madde) ile soru sorma (1 madde) olmak üzere 4 kategoriden oluşmaktadır. Bu çalışmada ise soru sorma kategorisine madde eklenmiş RTOP kullanılmıştır.

Çalışmanın verilerini boylamsal mesleki gelişim programına katılan iki katılımcı öğretmenin orta ve yüksek düzey ATBÖ uygulamalarının video kayıtları oluşturmaktadır. Öğretmenlerin ATBÖ uygulamalarının video kayıtları, öğretmenlerin söylemsel hamlelerini, öğrencilerin akıl yürütme becerilerini ve öğretmenlerin kullandığı iletişimsel yaklaşımları analiz etmek için deşifre edilmiştir. Öğretmenlerin orta ve yüksek düzey ATBÖ uygulamalarındaki sınıf söylemini araştırmak için yapılan deşifreler, söylem analizinin bir dalı olan sistematik gözlem yoluyla analiz edilmiştir (Mercer, 2010). Sistematik gözlem yaklaşımı, kodlama ve sayma olmak üzere iki aşamadan oluşmaktadır. Çalışmada, diğer araştırmacılar tarafından geliştirilen kod katalogları kullanılmıştır. Kodlama aşamasından sonra, öğrenci akıl yürütme kalitesi, öğretmenlerin kullandıkları iletişimsel yaklaşımlar ve söylemsel hamleler sayılarak frekans ve yüzde dağılımları belirlenmiştir. Sistematik gözlemin, "anlamların belirsizliği, anlamların zamansal gelişimi ve aynı görünüş biçimindeki ifadelerin oldukça farklı fonksiyonlara sahip olabileceği" gibi sınırlılıkları bulunmaktadır (Mercer, 2010, s. 4). Bu çalışmanın analizinde, sistematik gözlem yönteminin sınırlıklarının üstesinden gelmek için, içerik göz önünde bulundurulmuştur.

Bu çalışmanın ilk sorusunu cevaplamak için öğretmenlerin söylemsel hamleleri analiz edilmiştir. Soysal'ın (2019) "öğretmen söylemsel hamleler kodlama kataloğu" (SHKK) kullanılmıştır. Bu katalog, söylemsel hamlelerin türlerini ve işlevlerini gösteren 10 kategori, 34 alt kategori ve 200'den fazla analitik koddan oluşmaktadır. Lincon ve Guba (1985), gerektiğinde çalışmalara yeni kodlar eklenerek kataloğun revize edileceğini belirtmiştir. Bu çalışmada, kullanılan katalogda olmayan öğretmen söylemsel hamlelerine ihtiyaç duyulduğundan, SHKK'ye yeni kodlar eklenmiştir. İkinci araştırma sorusunu cevaplamak için, dersin her bir parçası, Mortimer ve Scott'un (2003) "iletişimsel yaklaşım türleri"ne göre kodlanmıştır. İletişimsel yaklaşım, öğretmenin, öğrencilerin fikirlerini dikkate alıp almadığını ve onların öğrencilerle etkileşim içinde olup olmadığını değerlendirmektedir. İletişimsel yaklaşım, etkileşimli-etkileşimsiz ve diyalojik-otoriter olmak üzere iki boyutta incelenmektedir (Mortimer ve Scott, 2003). Bu noktadan hareketle, iletişimsel yaklaşım dört temel tür türde incelenmektedir; diyalojik etkileşimli, diyalojik etkileşimsiz, otoriter etkileşimli ve otoriter etkileşimsiz. Üçüncü araştırma sorusunu cevaplamak için ise öğrenci cevapları "öğrencilerin akıl yürütme kalitesi çerçevesi"ne (Furtak ve diğerleri, 2010; Hardy ve diğerleri, 2010; Shemwell ve Furtak, 2010) göre kodlanmıştır. Bu çerçeve, sınıf söyleminde akıl yürütmenin ne ölçüde gerçekleştiğini incelemek amacıyla önceki çalışmalara dayanarak geliştirilmiştir (Furtak ve diğerleri, 2010). Akıl yürütme kalitesi dört tipolojiden oluşmaktadır. En basitten en karmaşığa göre söz konusu tipolojiler şunlardır; desteklenmemiş akıl yürütme, veri temelli akıl yürütme, delil temelli akıl yürütme, kural temelli akıl yürütme. Her bir soru için yapılan kodlamalarda, öğretmen söylemsel hamlelerinin, öğretmenlerin kullandıkları iletişimsel yaklaşımların ve öğrencilerin akıl yürütme kalitelerinin tekrar edilme sıklıkları belirlenmiştir. Her araştırma sorusunu cevaplamak için Öğretmen A ve Öğretmen B için bireysel durum analizi yapılmıştır. Bununla birlikte, durumlar arasındaki benzerlikleri ve farklılıkları belirlemek için karşılaştırmalı durum analizi yapılmıştır. Karşılaştırmalı durum analizi yapıldığında, öğretmenlerin farklı sınıf düzeylerinde ve farklı konularda uygulama yapmalarına rağmen sınıf söyleminin ve öğrencilerin akıl yürütmelerinin benzer olduğu görülmektedir.

Bu çalışmanın bulguları, öğretmenlerin orta ve yüksek düzey ATBÖ uygulamalarında hem diyalojik ve hem otoriter söylemsel hamleler sergilediğini göstermektedir. Sadece diyalojik ya da sadece otoriter söylemsel hamleler, ATBÖ uygulamasının amacını karşılamak için yeterli değildir çünkü öğretmen, diyalojik söylemler aracılığıyla öğrencilerin alternatif düşünme ve konuşma sistemini kullanmalarına izin verirken otoriter hamleler ile bilimsel düşünme ve açıklama sistemini kullanmalarına olanak sağlamaktadır (Soysal, 2007). Öğretmenlerin orta ve yüksek düzey ATBÖ uygulamalarındaki söylemsel hamleleri kıyaslandığında, bilgi sağlayıcı ve değerlendirici (BSD), iletişim (İLE) ve yansıtıcı söylem (YS) hamlelerinin görülme sıklığı yüzdelerinin en fazla değiştiği; modelleme (MOD), karşılıklı saygıyı sağlama (KSS), isimlendirme (İSİ), çeldirme (ÇEL), delillendirme (DEL) ve bilimsel süreç becerileri (BSB) hamlelerinin görülme sıklığı yüzdelerinin ise en az değiştiği gözlenmiştir. Öğretmenlerin, yüksek düzey ATBÖ uygulamalarında, daha az sıklıkla bilgi verdikleri ve öğrenci cevaplarını bilimsel bilgi bağlamında doğru veya yanlış şeklinde değerlendirdikleri görülmektedir. Dolayısıyla, öğretmenlerin yüksek düzey uygulamada sınıf söyleminin üçlü diyalog olarak IRF (soru sorma-cevaplama-değerlendirme) yapısının ötesine geçtiği ve öğrenci fikirlerinin keşfedildiği bir öğrenme ortamı olduğu söylenebilir. Öğretmenlerin pedagojik gelişimi boyunca BSD hamlelerinin görülme sıklığının değişimi RTOP'un öğrenci sesi, öğretmenin rolü ve akıl yürütme ile problem çözme becerileri kategorileri bağlamında öğretmenin gelişimine yansımış olabileceği düşünülmektedir. Ayrıca, YS hamleleri açısından, öğretmenlerin yüksek düzey ATBÖ uygulamalarında, öğrenci veya kendi söylemleri hakkında diğer öğrencilerden değerlendirme yapmalarını isteme ve öğrenci söylemlerindeki çelişkileri açığa çıkarma gibi hamlelerin sıklığı daha fazladır. Benzer bir şekilde diğer araştırmalar da ATBÖ uygulamasının kalitesi arttıkça öğretmenlerin, öğrencilerini birbirlerinin fikirlerini değerlendirmelerine ve fikirleri üzerine yansıtıcı düşünme yapmalarına daha fazla teşvik ettiğini bulmuşlardır (Kılıç, 2016; Kim ve El, 2015; Martin ve Hand). Yansıtıcı söylemler, öğrencileri fen kavramlarını kritik etmelerini ve bunlar hakkında değerlendirme yapmalarını teşvik ettiğinden argümantasyonun sosyal yönünü desteklemektedir (Berland and Reiser, 2011). Bu bağlamda, yansıtıcı söylemler, RTOP'un bütün kategorileriyle ilişkilidir. İLE hamlesi, öğretmenlerin orta ve yüksek düzey ATBÖ uygulamalarında çoğunlukla gerçekleştirdikleri hamlelerdir. Başka bir deyişle, öğretmenlerin öğrenci söylemlerinin altındaki akıl yürütme ve anlamı anlamaya yönelik hamleleri çoğunluktadır. Orta düzeyin aksine, yüksek düzey uygulamada, Öğretmen A'nın İLE hamlesi sıklığı daha fazla iken, Öğretmen B'ninki daha azdır. İLE hamlelerinin alt kategorilerine bakıldığında, Öğretmen A'nın yüksek uygulama düzeyinde "yeniden yapılanma" hamlesini %10 daha fazla sergilediği görülmektedir. Yeniden yapılandırma hamlesi, bilimsel bir kavramı öğrencilere tanıtırken ve öğrenci cevabını netleştirmek için kullanılmaktadır (O'Connor ve Michael, 1996). Bu nedenle, Öğretmen A'nın sınıfındaki öğrencilerin diyalojik etkileşime daha fazla dahil oldukları düşünülmektedir. Öğretmen A’nın İLE hamlesindeki artış da, RTOP’un kategorileri bağlamında Öğretmen B’den daha fazla gelişim göstermesi ile açıklanabilir. Soysal (2019) da İLE hamlelerinin öğrenci sesinin nicel olarak artmasına katkı sağladığını ifade etmiştir.

Öte yandan, MOD, KSS, İSİ, ÇEL, DEL ve BSD hamlelerinin sıklığı, öğretmenin pedagojik değişimi boyunca az değişen hamlelerdir. İlk beş hamle ise iki uygulama seviyesinde de nadiren gözlenmiştir. İlk olarak, MOD hamlesi öğrencilere bilim insanlarının nasıl çalıştığını göstermek için kullanılır; örneğin, veri toplama, ölçüm yapma, değişkenleri kontrol etme. Bu çalışmada, öğretmenlerin MOD hamlesini nadiren gerçekleştirdikleri görülmüş; bunun sebebi de öğretmenlerin sadece, öğrenciler çalışmalarını sınıf önünde sunarken ve bulguları hakkında birbirleriyle müzakere ederken bu hamleyi kullanmaya ihtiyaç duydukları şeklinde açıklanmıştır. KSS hamlesi, müzakerelerin devamlılığını sağlamak için, öğrencilere birbirlerini aktif bir şekilde dinlemeleri gerektiğinin ve tartışırken birbirlerini muhatap almaları gerektiğinin hatırlatılması şeklinde sergilenmektedir (Soysal, 2007). Bu çalışmada öğretmenler, ATBÖ uygulamaları boyunca, öğrenciler bilişsel ve fiziksel olarak aktif oldukları için sınıf yönetimini sağlamaya yönelik hamlelere nadiren ihtiyaç duymuşlardır. Öğretmenler, her iki uygulama seviyesinde de öğrencilerin sunumu sonunda kavramları müzakere etmedikleri için İSİ hamlesini sergilemeye ihtiyaç duymamışlardır. RTOP kategorileri doğrudan MOD, KSS ve İSİ hamleleri ile ilişkili değildir.

Öğretmenlerin, her iki uygulama düzeyinde de ÇEL ve DEL hamlelerini sergilemekte zorluk çektikleri görülmüştür. ÇEL ve DEL hamlelerinin, öğrenciler arası etkileşimi tetiklemeyi sağlayacak nitelikte olmakla birlikte, yüksek uygulama seviyesinde daha fazla serginlenmeleri beklenir. Aynı zamanda bu hamleler RTOP’daki bütün kategorilerle ilişkilidir. Öğretmenlerin bu hamlelerde zorlanmaları, uygulama öncesi hazırlıklarının eksik olması ile ilişkilendirilebilir.

İzleme (İZ) ve bilimsel süreç becerileri hamleleri (BSB), her iki uygulama seviyesinde de baskın olarak gözlemlenmiştir. Bu hamleler, ATBÖ uygulamalarının temel hamleleridir. İZ hamleleri, öğrencilerin sınıf söylemindeki müzakereyi izlemelerini ve tartışılan fikirler hakkında düşünmelerini sağlayarak öğrencileri bilişsel olarak aktif tutmaktadır (Soysal, 2007). Bu nedenle bu hamleler, öğretmenlerin ATBÖ uygulamasının büyük düşüncesine ulaşmalarına yardımcı olmaktadır. Ayrıca, BSB hamleleri, öğrencilerin günlük düşünme ve açıklama sistemlerini ortaya çıkarmak için çok önemlidir. Söz konusu söylemsel hamleler RTOP kategorilerindeki maddelerle doğrudan ilişkili olmamakla birlikte, bu maddelerin gerçekleşmesi için ön düzenleyicidir.

Bu çalışmada, ATBÖ uygulaması boyunca öğretmenlerin pedagojik gelişimine bakıldığında, öğretmenlerin boylamsal mesleki gelişim programı kapsamında bazı pedagojik stratejiler geliştirdikleri gösterilmiştir. Bununla birlikte, öğretmenlerin ÇEL ve DEL hamlelerini sergilemekte zorlandıkları görülmüştür. Bu açıdan çalışmanın bulguları, diğer çalışmalarla örtüşmektedir. Örneğin, Boyle, Lamprianou, and Boyle (2005), öğretmenler uzun soluklu mesleki gelişim programına katılsalar bile, pedagojik değişim zor olduğu için bütünsel olarak değişemediklerini ifade etmiştir.

Öğretmenler, yüksek düzey ATBÖ uygulamasında etkileşimli / diyalogik iletişimsel yaklaşımı daha fazla kullanırken etkileşimli / otoriter iletişim yaklaşımını daha az kullanmışlardır. Başka bir deyişle, öğretmenler, yüksek uygulama seviyesindeyken öğrenci görüşlerini daha fazla dikkate almışlardır. Alexander (2006) ile Benus vd. (2013), etkili sınıf söyleminin göstergesinin diyalojik söylem olduğunu söylerken, Mortimer ve Scott (2003), anlamlı öğrenme için diyalojik ve otoriter söylem arasında bir denge olması gerektiğini vurgulamaktadırlar.

Bu çalışmada, öğretmenler orta uygulama düzeyinden yüksek uygulama düzeyine geçtiğindeki BSD ve YS hamlelerinin görülme sıklığındaki değişimin, öğrencilerin akıl yürütme kalitesinin gelişimi ile ilişkili olduğu düşünülmektedir. Başka bir deyişle, öğretmenler daha az bilgi sağlayıp öğrenci cevaplarını değerlendirdikçe ve öğrencilere birbirlerinin fikirlerini değerlendirmesine daha fazla fırsat verdikçe, öğrencilerin delil temelli ve kural temelli akıl yürütmelerinin sıklığının arttığı, desteksiz ve veri temelli akıl yürütmelerinin sıklığının ise azaldığı görülmüştür. Diğer çalışmalar, üçlü diyalogdaki üçüncü hamlenin, öğrencilerin bilişsel katkısında önemli rol oynadığını göstermektedir (McNeill ve Pimentel, 2009; Soysal ve Yılmaz-Tüzün, 2019). Örneğin, öğrencilerin, cevapları doğru olarak kabul edildiğinde, iddialarını delil ve bilimsel ilkeler yoluyla desteklemeye ihtiyaç duymadıkları görülmüştür. Yapılan çalışmalar, YS hamlelerinin, öğrencilerin iddialarını gerekçeleriyle sunarak birbirlerini ikna ettikleri diyalojik etkileşimlere dahil olmalarına yardımcı olduğunu göstermektedir (Blosser, 1973, Chin, 2007; Martin ve Hand, 2019). Bununla birlikte YS hamleleri, öğrencilerin birbirlerine soru sormalarına da yardımcı olmaktadır (van Zee ve Minstrell, 1997).

Her iki uygulama düzeyinde de baskın olarak gözlemlenen İLE hamleleri, öğrencilerin akıl yürütme niteliklerine katkıda bulunmuştur. Öğretmenlerin pedagojik gelişimi doğrultusunda öğrencilerin akıl yürütme kaliteleri gelişse bile veri temelli ve desteksiz akıl yürütme sıklıkla görülmüştür. Bu bulgulara benzer olarak araştırmacılar, yüksek düzey ATBÖ uygulamasında bile öğrencilerin iddialarını delille destekleme ve delili tanımlama konusunda zorluk yaşadıklarını bulmuşlardır (McNeill vd., 2006; Benus vd., 2013). Bu çalışmada İLE hamleleri baskın olarak gözlemlenmesine rağmen ÇEL, YS ve DEL hamlelerinin az gözlenmesi öğrencilerin üst düzey akıl yürütmesini engellediği görülmüştür. Benzer şekilde, Soysal ve Yılmaz-Tüzün (2019), İLE hamlelerinin işlevinin, öğrencilerin üst düzey akıl yürütmelerini sağlayacak ortam oluşturan "ön-düzenleyici" olduğunu belirtmişlerdir.

Bu çalışmada, öğrencilerin bilişsel katkıları ve öğretmenlerin söylemsel hamleleri arasındaki ilişki, farklı uygulama seviyelerindeki farklı fen konuları bağlamında incelenmiştir. Fen konusunun içeriği, sınıf söyleminde öğrencilerin akıl yürütme kalitesini etkileyen bir faktördür (McNeill vd., 2006; Sadler, 2006). Bu çalışma, öğrencilerin akıl yürütme kaliteleri ile öğrenme talebi arasında ilişki olduğunu göstermektedir. Çalışmada uygulama yapılan ATBÖ konularında (üreme, büyüme ve gelişme; elektrik, kaldırma kuvveti ve ses) öğrencilerin günlük dillerini kullanmaya eğilim gösterdikleri görülmüştür. Öğretmenler, ÇEL, DEL ve YS söylemlerini sıklıkla kullanmadıkları için, öğrenciler sosyal dil ile bilimsel dil arasındaki farkı ayırt edememişlerdir. Bu yüzden, öğrencilerin delil temelli ve kural temelli akıl yürütme sıklığının az olduğu görülmüştür. Oysa öğretmenler, öğrencilere günlük dillerini kullanmalarına izin vermekle birlikle, onları, bilimsel dili kullanmalarına da ikna etmelidir (Morimer ve Scott, 2003). McMaho (2012), öğrencilerin, günlük hayattaki gözlemleri ile bilimsel açıklamalar arasında ilişki kurabilmeleri için öğretmelerin, desteksiz öğrenci fikirlerine yönelik hamleler yapmaları gerektiğini vurgulamaktadır. Chin (2006), ayrıca ÇEL hamlelerinin öğrencilerin bilimsel olarak yanlış cevapları üzerine yansıtıcı düşünmelerine ve yanlış muhakemelerini fark etmelerine katkı sağladığını belirtmiştir.

Bu çalışmada, iki ortaokul fen bilimleri öğretmeninin orta ve yüksek düzey ATBÖ uygulamalarındaki sınıf söylemi ve öğrencilerin akıl yürütme kalitesi araştırılmıştır. İlerleyen çalışmalarda daha fazla öğretmenle, farklı uygulama konularında ve farklı sınıf düzeylerinde çalışmalar yapılabilir. Ayrıca, saha gözlemleri ve görüşmeleri yapılarak çalışma derinleştirilebilir. Bu çalışmada, büyük grup tartışması analiz edilmiştir, ilerleyen çalışmalar küçük grup çalışmalarının söylem analizi yapabilir. Bununla birlikte, ATBÖ uygulamasının farklı aşamalarında öğretmenlerin kullandıkları söylemsel hamleler, iletişimsel yaklaşımlar ve öğrencilerin akıl yürütme becerileri incelenebilir.

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Soyadı/ Surname : Özkan İnal
Adı / Name : Gülşah
Bölümü / Department : İlköğretim Fen ve Matematik Alanları Eğitimi

TEZİN ADI/ TITLE OF THE THESIS (**İngilizce** / English) : INVESTIGATING SCIENCE TEACHERS' CLASSROOM DISCOURSE AND STUDENTS' REASONING QUALITY THROUGH ARGUMENT-BASED INQUIRY APPROACH

TEZİN TÜRÜ/ DEGREE**: Yüksek Lisans**/ Master ■ **Doktora** / PhD ☐

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