INVESTIGATING QUESTIONING PATTERNS OF TEACHERS THROUGH THEIR PEDAGOGICAL PROGRESSION IN ARGUMENT-BASED INQUIRY CLASSROOMS

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ABSTRACT

INVESTIGATING QUESTIONING PATTERNS OF TEACHERS THROUGH THEIR PEDAGOGICAL PROGRESSION IN ARGUMENT-BASED INQUIRY CLASSROOMS

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The purpose of this study is to delineate the characteristics of teacher questioning in different implementation qualities of Argument-Based Inquiry (ABI) teaching. With this purpose, first, the characteristics of teacher question types used in high quality ABI classrooms were described, and teacher questions used in high quality practices were distinguished from those posed in medium quality classrooms. Secondly, the study aimed to characterize the sequence of teacher question types that promote high cognitive level student responses.

The participants in this study were two elementary science teachers, teaching from 6^{th} to 8^{th} grades. The teachers were selected from a longitudinal professional development program that was conducted within the context of ABI approach in Turkey. The data of this study were collected through video records of teachers' classroom implementations. Data driven from classroom videos was analyzed by using multiple cross-case comparison.

The results revealed that teachers used similar proportions of close-ended and meta-cognitive questions in the high quality ABI practices. Meta-cognitive questions were defined for the first time in this study as the most effective question type to initiate high cognitive level student response. Moreover, the teachers asked the questions in a patterned order indicating a specific questioning sequence. This study provides teachers and researchers with cases rich in information regarding characteristics of teacher questioning used in high quality ABI classrooms by comparing them with those used in medium quality classroom practices.

Keywords: Argument-Based Inquiry, Teacher Questioning, Teacher Professional Development.

ÖZ

ARGÜMANTASYON TABANLI BİLİM ÖĞRENME SINIFLARINDA ÖĞRETMEN SORULARININ PEDAGOJİK GELİŞİMLERİ BOYUNCA İNCELENMESİ

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Bu çalışmanın amacı Argümantasyon Tabanlı Bilim Öğrenme (ATBÖ) yaklaşımının uygulandığı sınıflarda öğretmen sorularının farklı uygulama seviyelerine göre betimlenmesidir. Öncelikli olarak yüksek seviyedeki ATBÖ uygulamalarında sorulan öğretmen soruları tanımlanmış ve yüksek uygulama seviyesinde sorulan sorular ile orta seviye sınıf uygulamalarında sorulan sorular arasındaki farklılıklar incelenmiştir.

Çalışmada yer alan katılımcılar 2 fen bilimleri öğretmenidir. Katılımcılar, Türkiye'de ATBÖ bağlamında yürütülen boylamsal bir mesleki gelişim programına katılan öğretmenler arasından seçilmiştir. Çalışmaya ait veriler, öğretmenlerin kendi sınıflarında yaptıkları ATBÖ uygulamalarından alınan video kayıtlarından oluşmaktadır. Veriler çok durumlu karşılaştırmalı yöntem ile analiz edilmiştir.

Çalışmanın sonuçları, öğretmenlerin yüksek seviyede ATBÖ uygulamalarında benzer oranda kapalı uçlu ve üstbilişsel soru tiplerini kullandıkları göstermiştir. Üstbilişsel sorular, ilk defa bu çalışmada, öğrencinin yüksek bilişsel seviyede cevap vermesinde rol oynayan en etkili soru tipi olarak tanımlanmıştır. Ayrıca, öğretmenlerin soru tiplerini belirli bir sıralama kullanarak sorduğu gözlemlenmiştir. Bu çalışma, yüksek kaliteli ATBÖ sınıflarında sorulan öğretmen soru yöntemlerini orta seviye ATBÖ uygulamalarında sorulan sorularla kıyaslayarak öğretmen ve araştırmacılara zengin bilgiler sunmaktadır.

Anahtar Kelimeler: Argümantasyon Tabanlı Bilim Öğrenme, Öğretmen Soruları, Öğretmen Mesleki Gelişimi

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TABLE OF CONTENTS

PLAGIARISM iii
ABSTRACT iv
ÖZ vi
ACKNOWLEDGMENTS viii
TABLE OF CONTENTS ix
LIST OF FIGURES xiii
LIST OF TABLES xiv
CHAPTER
1. INTRODUCTION 1
1.1 Background of the Problem 1
1.2 Problem Statement 3
1.3 Purpose of the Study 7
1.4 Research Questions 7
1.5 Significance of the Study 7
1.6 Definitions of Terms 10
2. LITERATURE REVIEW 13
2.1 Shifting Indicators of Science Proficiency 13
2.1.1 Inquiry 15
2.1.1.1 Instructional Frameworks for Inquiry 16
2.1.2 Argumentation as a Central Tenet of Scientific Inquiry 19
2.2 Teacher Roles in the Classroom 23
2.3 Teacher Questioning 27
2.3.1 Question Classification Systems 29
2.3.1.1 Cognitive Hierarchy 30
2.3.1.2 Sophistication 33

2.3.1.3 Structure 35
2.3.2 Types of Questions Used in the Classrooms 36
2.3.3 Effect of Teacher Question Types on Student Learning 43
2.3.4 Discourse Patterns in the Classrooms 49
2.3.4.1 Analysis of Discourse Patterns 52
2.3.5 Why Aren't Teachers Asking The Effective Questions? 54
2.3.6 Improving Teacher Questioning 57
2.3.6.1 Milestones of Professional Development Programs 60
3. METHOD 63
3.1 Research Design 63
3.2 Research Context 65
3.2.1 The Professional Development Program 65
3.2.2 Participants 68
3.2.2.1 Teacher A 69
3.2.2.2 Teacher B 70
3.2.3 Criteria for Levels of ABI Implementation 72
3.3 Data Collection 73
3.3.1 Instrumentation 74
3.3.1.1 The Taxonomy of Question Types 74
3.3.1.2 The Coding Sheet of Cognitive Categories 81
3.4 Data Coding and Analysis 84
3.4.1 Individual Case Study Analysis 85
3.4.1.1 Research Question 1 85
3.4.1.2 Research Question 2 86
3.4.2 Cross-Case Comparison 87
3.5 Trustworthiness of the Study 88
4. RESULTS 90
4.1 Case Study of Teacher A 91
4.1.1 Comparison of Question Types between Medium and High-level ABI Implementations 91

4.1.1.1 Management Question Comparisons 93
4.1.1.2 Close-ended Question Comparisons 93
4.1.1.3 Open-ended Question Comparisons.. 94
4.1.1.4 Meta-Cognitive Question Comparisons 95
4.1.2 Comparison of Multiple Questions between Medium and High-level ABI Implementations... 95
4.1.3 Relationship between Teacher Questioning Patterns and Student Cognitive Operations in Medium and High-level ABI Implementations........................... 97
4.2 Case Study of Teacher B 104
4.2.1 Comparison of Question Types between Medium and High-level ABI Implementations... 104
4.2.1.1 Close-ended Question Comparisons 105
4.2.1.2 Open-ended Question Comparisons.. 107
4.2.1.3 Meta-cognitive Question Comparisons... 107
4.2.2 Comparison of Multiple Questions between Medium and High-level ABI Implementations... 107
4.2.3 Relationship between Teacher Questioning Patterns and Student Cognitive Operations in Medium and High-level ABI Implementations......... 108
4.3 Cross-case Analysis Results of Two Cases 117
4.3.1 Research Question 1 117
4.3.2 Research Question 2 118
5. DISCUSSION.. 121
5.1.1 Discussion of the Findings... 121
5.1.2 Limitations 130
5.1.3 Implications of the Study 131
5.1.4 Recommendations for Future Research 132
REFERENCES.. 134
APPENDICES... 160
APPENDIX A The Modified Reformed Teaching Observation Protocol (RTOP)........ 160
APPENDIX B TURKISH SUMMARY 161

APPENDIX C TEZ FOTOKOPİSİ İZİN FORMU 173

LIST OF FIGURES

FIGURES

Figure 4.1 Distribution of Teacher Question Types by Implementation Level-Teacher A ... 92
Figure 4.2 Distribution of Teacher Question Types by Implementation Level-Teacher B . 104

LIST OF TABLES

TABLES

Table 2.1. Central Components of ABI Classroom and Connections with the Teacher and Student Roles 25
Table 2.2. Representative Question Classification Systems 31
Table 2.3. Comparison of Teacher Questioning in Traditional and Constructivist Teaching 51
Table 3.1. The Content and Structure of the PD program 68
Table 3.2. Information regarding the Classroom Implementations 71
Table 3.3. The Taxonomy of Question Types 78
Table 3.4. Cognitive Categories and Definitions of Each 82
Table 4.1. Frequency and Percentage of Questions from Each Type for Each Implementation Level-Teacher A 94
Table 4.2. Example of the Teacher Use of Multiple Question Strings in HLABIP-Teacher A 96
Table 4.3. The Distribution of the Cognitive Level of Student Answers for Each Question Type and Each Implementation Level-Teacher A 98
Table 4.4. Examples of the Different Roles that Meta-Cognitive and Management Questions Served in Student Response in HLABIP 100
Table 4.5. Example of Teacher Interaction with Students at the Beginning of the Whole-Class Discussion in MLABIP 102
Table 4.6. Frequency and Percentage of Questions from Each Type for Each Implementation Level-Teacher B 106
Table 4.7. Example of the Teacher Use of Multiple Question Strings in MLABIP-Teacher B 108
Table 4.8. The Distribution of the Cognitive Level of Student Answers for Each Question Type and Each Implementation Level-Teacher B 109
Table 4.9. Example of Teacher Interaction with Students at the Beginning of the Whole-Class Discussion in HLABIP 110
Table 4.10. Example of Teacher Interaction with Students at the Whole-Class Discussion in HLABIP 112
Table 4.11. Example of Teacher Interaction with Students at the End of Whole-Class Discussion in HLABIP 115

CHAPTER 1

INTRODUCTION

1.1 Background of the Problem

Current science education reforms in both national and international settings explicitly suggested Argument-Based Inquiry (ABI) practices in order to be able to educate successful individuals in a world dominated by scientific and technological innovations. The current indicators of science proficiency emphasized shifting view away from traditional paradigms in which learning perceived as a recall of factual information to more student-oriented learning environments, where learning process occurs through construction of own knowledge instead of transmission of it. In this process, learners should be provided opportunities to practice not only exploration and experimentation but also explanation and argument (Turkish Ministry of National Education [MoNE], 2013). Similarly, National Research Council's (NRC) most recent report in the USA, *A framework for K-12 science education* (2012), highlighted the requirement of student engagement in data collection and laboratory work as well as construction of knowledge through social processes such as negotiation of explanations. The emphasis on practicing both inquiry investigations and argumentation in science learning primarily emerged from the need to practice science in a similar way that of scientists.

This shift in science education reform movements required significant teacher changes in teaching practices. The research on teacher change put emphasis on the role of teacher questioning in order to be able to improve classroom practices to more student-oriented way as suggested by science education reform movements. Teachers' use of specific questioning strategies is a significant factor affecting their pedagogic development in science classrooms (Benus, Yarker, & Hand, 2010; Martin & Hand, 2009; McNeill & Pimentel, 2010; Oliveira, 2010; Pimentel, Katherine, & McNeill 2013, Pinney, 2014; Promyod, 2013). Teachers are required to develop questioning skills and should possess deep understanding regarding questioning techniques in order to be able to implement effective ABI classrooms (Martin & Hand, 2009; Omar, 2004; Pimentel, 2010; Promyod, 2013). In this sense, Norton-Meier, Hand, Hockenberry and Wise (2008) put emphasis of the role of questioning on creating dialogical interactions, which is a key element of ABI learning environments. Students should be engaged in negotiation of meaning with their peers, and the teacher in small or large group discussions. Whereas this practice occurs in the form of a monologue in traditional classrooms in which teachers are the authority of the talk, the ABI learning environments require experiencing dialogue instead of monologue where individuals scaffold their own knowledge through talking and listening each other. Although it is challenging for teachers to change their position of authority in the conversation to more flexible and student-centered way, using specific questioning strategies has a significant role to achieve this flexibility (Norton-Meier, Hand, Hockenberry, & Wise, 2008).

Many educators have emphasized the need for effective questioning when shifting to student-centered learning paradigms to increase student talk in classroom conversations (Martin & Hand, 2009); to create dialogical interactions (Gunel, Kingir, & Geban, 2012); to challenge and support student practices of cognitive functions in initiating higher-level scientific thinking among students (Chin, 2007; Oliveira, 2009). Classroom investigations on teacher questioning mostly focused on the cognitive functions that the questions demand in the response (Cotton, 2001; Gall, 1970). Many research on classroom questioning cited the reason behind examining questions in relation to cognitive functions based on the study of Vygotsky (1978) on language and social interaction in the process of human development and learning.

Vygotsky (1978) emphasized the importance of social interactions in the cognitive development process of individuals. Any development occurs first through social interactions within individuals' "inter-psychological" planes, and then within "intra-psychological" planes (Vygotsky, 1978, p21). This suggests that student cognitive development can be identified by examining the structure and contents of social interactions. Vygotsky (1978) believed that each learner has a zone of proximal development, which tells us about the range from what learners can do without assistance to what they can accomplish with assistance. The assistance by peers or teachers is determined by the researcher to provide learners opportunities to function higher cognitive skills than without assistance. Teacher's use of effective questions as one of the identifiers of social interactions in a classroom provides students assistance to enhance the quality of their cognitive functions (Dantonio & Beisenherz, 2001; Fairbain, 1987; Gallagher & Aschner, 1963; Hus & Abersek, 2011).

1.2 Problem Statement

The critical importance of questions in initiating high cognitive functions requires teachers to be professional questioners (Gall, 1984). There are various considerations to assess what is a professional questioner in education literature. One of these considerations and the most notable one is examining teacher question types based on the type of cognitive process it requires (Gall, 1970). Chin (2007) elicited the rationale on examining the types of questions by stating, "The kinds of questions that teachers ask and the way teachers ask these questions can, to some extent, influence type of cognitive processes that students engage in as they grapple with the process of constructing scientific knowledge" (p. 817). Similarly, Pate and Bremer (1967) gave insight into the researchers' attempt to examine teacher question types by claiming that "The teacher's effectiveness in questioning depends on an awareness of various purposes that questions may serve and an awareness of different types of questions for achieving these purposes" (p. 422). In this regard, various studies attempted to characterize teacher question types based on the cognitive demand that the questions place on student response. Effective teacher questioning was mostly associated with teacher's ability to ask questions that initiates higher level cognitive practices (Dantonio & Beisenherz, 2001). Educators agreed that teacher questions should serve improvement of various cognitive or thinking skills rather than engaging students in learning of factual information (Aschner, 1961; Carner, 1963; Hunkins, 1966). However, the studies in education literature commonly found that teachers tend to pose lower-level or factual-recall questions, which require specific information in response and place few cognitive demands on students (e.g.; Dantonio & Beisenherz, 2001; Hamm & Perry, 2002; Newton & Newton, 2000; Yip, 2004).

In an attempt to improve teacher questioning strategies, several research implemented teacher training programs and found that teachers asked more high cognitive level questions than lower-level ones after the training program (e.g., Erdogan & Campbell, 2008; Martin & Hand, 2009). Several studies, on the other hand, revealed that it wasn't necessarily required to use higher level questions more frequently than lower level ones for effective questioning (e.g., Goodwin, Sharp, Cloutier, & Diamon, 1983; Konya, 1972). For instance, Konya (1972) observed in his study that the classrooms where students were exposed to similar proportions of higher-level and lower level question types (50 percent) were the most effective in initiating student high-level response. High-level questions are widely accepted to be categorically better to promote high-level student practices but it is controversial in the literature whether teachers need to use more higher-order questions in high quality questioning.

Additionally, by investigating the types of teacher questions in relation to student responses, several researchers (e.g., Dillon, 1982; 1988; Harrop & Swinson, 2003; Mills, Rice, Berliner, & Rousseau, 1980) observed that more than half of the student responses were in lower-level even when teachers asked a higher-level question. Similar evidence was provided by Dillon (1982) by stating, "Ask a higher-level question, get any level answer" (p. 549). The research investigating the impact of high cognitive level questions on initiating high-level response found contradictory findings (Redfield & Rousseau, 1981; Winne, 1979). While several researchers observed direct correlation, several have shown that asking a high-level question does not ensure that students' response will be in high-level. Gall (1970) argued the reason behind asking high-level questions and getting low level answers that it can be related with ineffective question classification systems. Many of the question classification systems were developed based on investigation of teacher question types which were actually observed in a classroom rather than considering the types of questions which teacher should use (Gall, 1970). Gall further suggested examining the sequence of teacher question types. Investigating teacher question types undoubtedly have significance to determine high quality questioning in classroom practices; however, the questions should not be considered as isolated from each other (Gall, 1970). In this sense, for instance, Taba (1966) revealed that teachers should give a direction to discussion first by asking factual-recall or lower-level questions and then, should manipulate ideas with higher cognitive questions. Although the suggestion to examine sequence of teacher question types was made in 1970s, since then, there is not any accessible study addressing the relationship between the sequence of teacher question types and student higher-order cognitive responses.

In order to address effective teacher questioning or to improve teacher questioning skills, several studies implemented professional development programs and investigated teacher questioning behaviors before and after the programs. The need for training programs to improve teacher questioning strategies was emphasized by many researchers (e.g., Dantonio, 1990; Fairbain, 1987; Joyce & Showers, 1983; Otto & Schuck, 1983; Savage, 1998). Although researchers have pointed out the need for teacher professional development in effective questioning over a century, there are limited studies on examining teacher questioning along with professional development programs (Bolen, 2009).

The characteristics of professional development programs show variety in the research of classroom questioning. Researchers argued that even though the focus of the training program is a specific skill or practice; it should be conducted by considering teacher beliefs, knowledge, habits of practice that they deeply hold. Teacher's "epistemology must become an explicit target of change. Without such change as a priority, efforts directed at teacher development become narrowly focused on changing the kinds of attributes and skills that may be added to, subtracted from, or modified" (Windschitl, 2002, p. 143). Similarly, Haney, Czerniak and Lumpe (1996) discussed the requirement of a special attention into teacher cognition and beliefs while improving teacher specific skills. In this regard, even if the studies aim to improve teacher questioning skills, the professional development programs should not only focus on improving individual questioning strategies but also address teacher beliefs, perceptions, and habits of practice that they hold. Examining the characteristics of questioning studies, two types of research has emerged in this context. One type is those training teachers with an individual focus on questioning skills (e.g., Bolen, 2009) and the other type aims improvement in questioning with a holistic focus on teacher pedagogic practices (e.g., Erdogan & Campbell, 2006; Martin & Hand, 2009). However, studies favor the need for focusing on teacher whole pedagogy considering the beliefs and perceptions in order to attain a development in any specific strategy. Additionally, majority of the studies were conducted as short-term sessions; it is not common to examine teacher pedagogic practices in sustained, long-term programs (Benus, Yarker, Hand, & Norton-Meier, 2013). One session training programs, which are called by Budde (2011) as "one-shot session, sit-and get and one size fits all approaches" (p. 21) are very common types of the teacher professional development (Darling-Hammond, 2005; Darling-Hammond & McLaughlin, 1995; Lieberman, 1995; Shibley, 2006; Xu, 2002). In this regard, in education literature, there is a need for studies investigating teacher professional development in longitudinal programs in which teacher beliefs, perceptions, and habits of practice were addressed.

1.3 Purpose of the Study

The main purpose of the study was to delineate the characteristics of teacher questioning in different classroom implementation qualities of ABI teaching. Specifically, first, the characteristics of teacher question types used in high quality classrooms were described, and teacher question types used in high quality ABI practices were distinguished from those posed in medium quality classrooms. The reason to make the comparison of teacher question types between medium and high quality classrooms lied behind not only delineating the features of high quality questioning but also providing insight into the differences occurred when teachers attempted to improve their questioning practices. Secondly, the study aimed to characterize the sequences of teacher question types that promote high cognitive level of student responses. The sequences of teacher question types used in medium and high quality classrooms were examined in relation to student responses. In this way, it was aimed to determine whether teachers used the question types in a patterned order specifying a particular questioning sequence in order to initiate high cognitive level responses.

1.4 Research Questions

There are two questions that guide this study.

1. What are the differences in teacher question types occurred in medium and high-level ABI teaching practices?
2. What are the main characteristics of teacher questioning patterns in medium and high-level ABI teaching practices?

1.5 Significance of the Study

As the reform movements in both national and international settings recommended ABI practices in science classrooms to educate successful citizens, it is significant to take a closer look into these classrooms. As Patton (1987) suggested that it is important to describe teaching mechanisms of teachers as they implement effective classroom practices. In this regard, the present study provides cases rich in information to teachers and researchers on the characteristics of questioning associated with medium and high quality ABI learning environments. The rationale behind investigating questioning in different quality levels of classroom practices primarily emerged from the research indicating that teacher quality of classroom implementations is highly related with the quality of questioning (Martin & Hand, 2009; Omar, 2004; Pimentel, 2010; Promyod, 2013). Whereas questioning strategies in high-level ABI practices delineate the characteristics of high quality questioning, the comparison between the medium and high quality classrooms provides some insight into the differences occurred when teachers attempted to improve their questioning.

Teachers' use of specific questioning strategies is a significant factor affecting their pedagogic development in science classrooms (Benus, Yarker, & Hand, 2010; Martin & Hand, 2009; McNeill & Pimentel, 2010; Oliveira, 2010; Pimentel, Katherine, & McNeill, 2013). This significance arises from the role of questioning in such as increasing student talk (Gunel, Kingir, & Geban, 2007; Martin & Hand, 2009), starting and guiding the classroom negotiation (Gunel, Kingir, & Geban, 2007; Kawalkar & Vijapurkar, 2013), implementation of scientific argument (Martin & Hand, 2009); improving reasoning and justification for explanations (Benus, Yarker, & Hand, 2010), all which are key features of ABI classrooms (Piburn et all., 2000). Examining interaction patterns in classrooms including teacher questions and student responses is significant to understand how to encourage student practices of cognitive skills (e.g., problem solving, decision making) since these skills are necessary to be able to contribute democratic society (Bolen, 2009). Teacher questions have so critical importance in initiating various cognitive functions (Aschner, 1961; Carner, 1963) that teachers need to be professional questioners (Gall, 1984). Various studies have been conducted throughout time in order to understand what a professional questioner is or what is an effective teacher questioning but only limited of them was carried out within ABI classrooms (Erdogan & Campbell, 2006; Kawalkar & Vijapurkar, 2013; Pinney, 2014).

Classroom investigations on teacher questioning mostly assumed that higher-level questions were categorically better to promote high-level responses; however, it is consistently found that teachers pose predominantly cognitive-memory or factual-recall questions (Cunningham, 1977; Dantonio & Beisenherz, 2001; Gall, 1970; Graesser & Person, 1994; Greenough, 1976; Hamm & Perry, 2002; Newton & Newton, 2000; Yip, 2004). Whereas these studies evaluated teachers' dominant use of factual-recall questions as an ineffective questioning, several studies indicated that it does not necessary to use mostly high-level questions in classroom practices (Goodwin et al., 1983; Konya, 1972). Although higher-level questions are perceived to be categorically better to promote high-level responses, it is contradictory in questioning literature that in which proportions question types should be used for an effective questioning. By examining the questioning in high quality classroom practices, this study may make significant contributions on the proportions that questions types are used in effective questioning.

Additionally, the studies on teacher questioning mostly attempted to characterize questioning strategies in high quality classroom practices without examining the impact of them on student responses (e.g., Cikmaz, 2014; Erdogan & Campbell, 2006; Martin & Hand, 2009). These studies described teacher questioning strategies in high quality classrooms by assuming that questioning in high-level practices meet all the inquires that teacher questions desire in the response. The present study has distinctive significance compared to those of others that high quality teacher questioning was described by not only investigating it in high quality classroom practices but also by examining the impact of teacher question types on the cognitive level of student responses. The determination of the match between the cognitive level of teacher questions and student responses is called by Dillion (1982) as cognitive correspondence. The primary reason to examine the cognitive correspondence between the questions and responses in this study emerged from the research findings stating higher-level questions will not always result in high-level cognitive responses. By examining the cognitive correspondence, several researchers (e.g., Dillon, 1982; 1988; Harrop & Swinson, 2003; Mills, Rice, Berliner, & Rousseau, 1980) observed that even though teacher asked higher level questions, student answers were mostly in low cognitive level. This study may have significant contributions on the relation between the level of questions and responses.

As was mentioned previously, this study examined question types and patterns of teachers by comparing their medium and high quality ABI classroom practices. Different quality implementations were achieved throughout a longitudinal (3-year) PD program. While medium quality practices corresponded to 3rd implementation semester (18th month) of the program, high quality occurred in 4th implementation semester (24th month) in the PD program. The focus on these semesters has significance in terms of achieving permanent shift in teacher pedagogic practices. Gunel and Tanriverdi (2012) reported that the changes in teacher pedagogic practices remain permanent after the 18 months of a longitudinal training period. Teachers need to be trained at least 18 months in order to observe significant shifts in their pedagogic practices (Martin & Hand, 2009; Tanriverdi & Gunel, 2012). However, research on improving teacher pedagogic practices was widely conducted in short-term PD programs (Darling-Hammond, 2005; Darling-Hammond & McLaughlin, 1995; Lieberman, 1995; Shibley, 2006; Xu, 2002). In this regard, the findings of this study that were attained at a longitudinal program attach distinctive significance when compared to those of others revealed at short-term PD programs.

1.6 Definitions of Terms

Types of Teacher Questions: Four major types of questions were used in this study. These are management, close-ended, open-ended and meta-cognitive questions. Management questions were defined as those used to manage or understand student directions as they are completing assignments in the classrooms (Graesser & Person, 1994). Close-ended question type engages students in short-answers which are usually in the form of recall of factual information (Graesser & Person, 1994). Open-ended questions require long answers, in which students interpret, organize and compare information (Graesser & Person, 1994). Meta-cognitive question types were defined as those invite students to experience reasoning, negotiation of meaning with others and planning new experiments. Whereas the definitions of management, close-ended and open-ended questions were adopted from the study of Graesser and Person (1994), the definition of meta-cognitive questions were emerged in the present study by examining the impact of teacher question types on learner responses.

Cognitive Level of Teacher Questions: The cognitive level of teacher questions affects the type of cognitive processes that students involve in the response (Chin, 2007). Low-level questions or lower cognitive level questions were defined as those require low-cognitive level answer in which students experience recall of factual information and explanation of a phenomenon or process (Graesser & Person, 1994). This type of questions place few cognitive demands on students. Close-ended and open-ended questions, which were developed by Graesser and Person (1994), were associated with low-level question types within the scope of this study. High-level questions or higher cognitive level questions were defined as those invite high cognitive level answer in which students involved in reasoning, negotiation of meaning with others and planned new experiments (Grimberg & Hand, 2009). Meta-cognitive questions were determined as to be high-level question type in the present study.

Teacher Questioning Patterns: Questioning pattern was defined as the sequence of teacher question types. Sequencing is a strategy for effective questioning in order to determine whether teacher uses the question types in a patterned order indicating a purposeful questioning technique.

Cognitive Level of Student Reponses: Three major cognitive levels were adopted from the study of Grimberg and Hand (2009). These are low-level (perception), medium-level (conception), and high-level (abstraction) cognitive functions. Lower cognitive level responses are based on perception. They require students to practice o*bservation, measurement* and *comparison,* which are noncomplex, one dimensional operations. Medium cognitive level responses are based on conception, in which students experience the practices of *analogy,* c*larification, claim* and *cause/effect* operations. High-level responses require students to experience abstraction such as *induction/generalization*, *deduction, investigation desig*n, and *argumentation.* These are also defined as multi-domain operations.

Argument-Based Inquiry (ABI): The ABI approach is an argument-immersed inquiry approach to experience science. As Cavagnetto (2010) identified:

> 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. Immersion-oriented interventions were designed to embed argument within student explorations of science principles. That is, argument was not considered something that was done to conclude the inquiry but was found throughout the inquiry as students generated questions, designed experiments, interpreted data, and constructed and defended evidence-based knowledge claims based on their evidence (p.351).

Implementation Level of ABI Teaching: The classroom implementation of each teacher was ranked as medium-level and high-level based on the measure of degree to which the classroom reflects the key characteristics of ABI teaching. Assigning numbers to each implementation enabled differentiation of quality of ABI teaching among the classrooms. Whereas high implementation level of ABI teaching meets all the inquires of what science reform movements suggest for effective science teaching, medium implementation level served to more traditional transmission of knowledge compared to high-level implementations.

CHAPTER 2

LITERATURE REVIEW

This chapter will first review the literature on shifting indicators of science proficiency toward implementation of ABI approach in order to provide insight into teacher changing roles in science classrooms. Teacher questioning as having a significant focus among these roles will then be addressed considering the role of it in classrooms. After that, what research reveals about teacher questioning and the ways to improve questioning strategies will be explained. Professional development (PD) programs as key processes to develop teacher questioning skills will then be addressed in detail since the study was conducted in the context of a PD program.

2.1 Shifting Indicators of Science Proficiency

The indicators of science proficiency may change at a historic time in order to meet the requirements of the changing world. In the National Research Council's (NRC) most recent report, *A framework for K-12 science education* (2012), for instance, the need for the development of current standards was explained with the achievement gaps that emerged from increasing student diversity in the nation. The changes in student demographics in a classroom resulted in achievement gaps in science, and required teachers to make shifts in their instructional methods in order to make science education accessible for all students. The NRC (2012) further emphasized that all the new standards were developed in order to be able to educate individuals those are career ready and successful in a world fueled by innovations in science and technology.

The new indicators of science proficiency highlighted the shifting view away from classrooms heavily depend on textbooks, teachers' direct instruction, and a learning concept that explained as recall of factual information. Students cannot simply assimilate "knowledge as it is presented, but impose their existing frameworks of knowledge to incorporate and invent new knowledge" (Putnam, Lambert, & Peterson, 1990, p. 42). Thus, teaching practices should provide students opportunities with actively participating in the learning process in order to support construction of knowledge instead of transmission of it. Similarly, Erduran, Simon and Osborne (2004) underlined the significance to move away from transferring of factual information to learning process in which individuals construct theories about the natural world. Science teaching should not only focus on learning of the scientific facts but also on practices, methods of science as well as its nature of a social practice (Driver, Newton, & Osborne, 2000; Ford, 2008).

By deeply examining the shifts in the view of science teaching, it appears that classroom inquiry has central importance in science education reforms for many decades since it has potential to engage students in active learning environments. The need for inquiry in science curriculums is not only evident in international contexts but also in reforms movements of Turkish educational system. As is similar to developed countries, such as USA, Spain and Australia, inquiry-based science teaching has emphasis in Turkish educational setting. By comparing the science reform movements in international and national setting, Akpinar and Aydin (2007) asserted that whereas the developed countries achieve educational reforms based on inquiry for many decades, it was 2004 in Turkey that curriculum in science education underwent a big revolution to align with inquiry-based teaching. The changing views toward inquiry teaching, definition and significance of it will be addressed later in the current study by considering both national and international education settings in order to provide a deeper insight into it.

2.1.1 Inquiry

The need for inquiry has always been on the heart of science education over time; however, the term ‘inquiry’ has been defined in various ways by teachers, researchers, and science educators (Crawford, 2007). Next Generation Science Standards (NGSS) interpreted inquiry as “major practices that scientists employ as they investigate and build models and theories about the world” (NGSS Lead States, 2013, p. 2). According to Bybee (2006), inquiry in science teaching has two meanings in The National Science Education Standards: inquiry as outcomes of science teaching and inquiry as teaching strategies. Inquiry as outcomes of science teaching refer to “specific skills and abilities integral to the processes and methods of science” whereas, inquiry as teaching strategies refer to instructional techniques used to “achieve students’ knowledge and understanding of science concepts, principles, and facts and/or the outcomes” (Bybee, 2006, p. 454). While inquiry can be defined in various ways, this study will address the inquiry mostly as teaching strategies by referring to teachers’ pedagogical actions to initiate scientific practices.

The reforms in science education defined their expectation in inquiry approaches that students should be able to engage in investigations in order not to learn about them secondhand (NRC, 2012; 2000; 1996). In other words, students need to understand the nature of scientific knowledge by practicing science themselves. The requirement of student direct practice of science emerged from the idea of investigating science in a similar way that scientists do (Akkus, Gunel, & Hand, 2007; Bliss, 2008; Chinn & Malhotra, 2002; Jiménez-Aleixandre & Erduran, 2008; NRC, 2012). Teaching science by inquiry involves student experience of processes and thinking skills used by scientists (Wilcox, Kruse, & Clough, 2015). Ministry of National Education (MoNE, 2006) in Turkey described these processes as knowledge of and ability to make observations, gather, test, and interpret data, formulate hypothesis, confirm or reject hypothesis, and consider alternative explanations. According to Curry-Sumrall (2010), scientists believed that inquiry-based practices enhance individuals’ ability to investigate independently. That is, use of these practices improves student skill to discover knowledge on their own. Curry-Sumrall elaborated the impact of this ability in a way that students have opportunities to become life-long learners and develop higher level cognitive skills.

Teaching science through inquiry further contributes to achievement of all students regardless of their demographic differences. Inquiry experiences provide all students including those with learning and language barriers opportunities to understand abstract concepts (Bransford, Brown, & Cocking, 2000). Secker (2002) studied the impact of teacher practices on science achievement of students having different demographic backgrounds. She found that science achievement has been directly related to socio-economic, minority and gender status when teacher use conventional methods. Inquiry-based teaching, on the other hand, leaded to higher achievement for all students through improving an individual construction of meaning. The researcher, finally, reported that teaching through the use of inquiry not only develops achievement for all students, but also reduces the gap among those having different demographic backgrounds.

The above mentioned importance of inquiry has never been diminished in science classrooms over time; however, suggested frameworks to adopt it have been changed. This change might arise from the shifting views toward teaching and learning in science education. As Killion (2002) reported that the shift in education from teaching-centered to learning-oriented view requires changes on how teachers teach. Since inquiry may refer to teachers' pedagogical actions to initiate scientific practices as suggested by Bybee (2006), it is not surprising that the way how to adopt inquiry is undergone changes based on the education reform movements.

2.1.1.1 Instructional Frameworks for Inquiry

One of the first instructional frameworks to adopt inquiry was 3E learning cycle, which was recommended by Atkin and Karplus (1962) and later expanded upon by Lawson (1995). In this design, the 3E refers to three phases of learning cycle, which are exploration, explanation and expansion, respectively. In the exploration phase, students are required to gather data and to solve problems. During the second phase, explanation, students are expected to accommodate new understandings through interpretations of collected data with the guidance of teacher. In the final phase, expansion, students verbalize their new understandings considering previously hold ideas.

Bybee (1997) redesigned the 3E learning cycle based on the assumption that teachers should engage students in a more active learning environment. He developed 5E Model of inquiry by adding two more stages to original three phases. The 5E Model includes engage, explore, explain, elaborate, and evaluate. The engage phase requires teachers to draw student attention through open-ended questions, demonstrations or discrepant events. Students are expected to make connections between past and current learning experiences, and should mentally engage in the learning process. Afterwards, students are provided opportunities to explore the topic by experiencing a series of activities, and to construct explanations based upon the experiences in the investigations. In the elaborate stage, students are encouraged to apply their new understandings to a new situation. Lastly, student understanding is evaluated by themselves as well as by teachers through both formative and summative assessments (Bybee et al., 2006).

At a later time, Bybee's 5E model was modified to 7E's by Eisenkraft (2003). His first suggestion was adding an elicit stage before the engage phase in order to reveal student prior knowledge regarding the topic. The second suggestion was to include an extend phase to the elaborate stage in order to give much emphasis on student practice of new understandings from one situation to another. The main purpose of this additional stage is to increase the likelihood that students are able to transfer their learning to different concepts and contexts.

In recent years, the view in how to adopt inquiry in science classrooms has emerged from the changing focus of an instruction solely on exploration and experimentation to explanation and argumentation. With this shift, the view on classroom inquiry has changed from a mostly individual activity to one which is immersed in social processes. The NGSS specified the key practices in science classrooms so as to meet the standards as the followings: “asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, obtaining, evaluating and communicating information” (NRC, 2012, p. 42). These practices are the way to develop student communication and thinking skills such as critical thinking and inquiry-based problem solving, which are needed to be successful citizens in a world fueled by innovations in science and technology (NRC, 2012). The emphasis on these practices describes that scientific practices do not only include data collection and laboratory work but also construction and negotiation of explanations (Choi, Hand, & Norton-Meier, 2014). Moreover, the Benchmarks for Scientific Literacy describe scientific investigations as “the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence” (American Association for the Advancement of Science, 1993, p. 12). Newton, Driver and Osborne (1999) has pointed out the significance of constructing and critiquing claims in learning environments in a way that science discourse should be promoted in the light of student own thinking and that of experts. These types of practices, thinking and critiquing aligns with the argument-embedded inquiry investigations (Enderle, Grooms, Campbell, & Bickel, 2013). Development of arguments based on evidence and justification while engaging students in inquiry practices are skills now considered as part of the overarching goals of science literacy.

As is similar to above exemplified reform movements, the emphasis of argumentation as an integral part of scientific inquiry was explicitly addressed in Turkish education setting by MoNE (2013). The current science curriculum was designed by handling inquiry as not only a process of “exploration and experimentation” but also practicing of “explanation and argument” (MoNE, 2013). Learners are expected to generate evidence-based arguments while exploring the physical and natural world. This experience was also referred as practicing hands-on and minds-on science in the construction of scientific knowledge.

2.1.2 Argumentation as a Central Tenet of Scientific Inquiry

Argumentation is a scientific discourse referring to ways that evidence was applied in reasoning (Kelly, 2007). Science argumentation can be thought of promoting knowledge claims, providing evidence for these claims and critiquing of those evidence and claims through listening, writing and talking (Duschl, Schweingruber, & Shouse, 2007). On individual basis, a person constructs his or her own understanding to support own thinking. The individual justifies his or her own ways of knowing through reasoning and empirical evidence (Driver, Newton, & Osborne, 2000). In this context, individuals first argue by themselves to develop their claims and then carry it to social basis. In explaining the argumentation on social basis, McNeill (2009) addressed argumentation as a process of individual writing or speaking to inform or convince others on these claims. The researcher pointed out that argumentation takes place in both individual and social levels; however, it is the social aspect as integral components of science. Argumentation is language-based social process since it requires both internal interaction and interacting with the thoughts of others.

The practice of scientific argumentation, which necessitates interpretation, critique and refinement of data and evidence (Duschl & Osborne, 2002; Osborne, Erduran & Simon, 2004), assists learners to improve scientific habits of mind (Sandoval & Reiser, 2004), to comprehend the content of science (Zohar & Nemet, 2002), and to practice and improve scientific thinking (Kuhn, 1992; Kuhn, Shaw, & Felton, 1997) and reasoning (Chinn & Anderson, 1998; Choi, 2008). Without argumentation, students cannot develop abilities to construct and critique knowledge (Ford, 2008). If students are not provided opportunities to critique knowledge, they expose to the idea that their ideas are uncontested or unquestionable (Berland & Reiser, 2009). However, when provided, for instance, student starts to ask ‘why’ questions instead of ‘what’ questions (Duschl, 1990). ‘Why’ questions ensure that students construct conversations and critique on data and evidence in a similar way that of scientists (Bricker & Bell, 2008). Additionally, argumentation provides students with opportunities to conceptualize the thoughts of others that in turn, as Vygotsky (1987) highlighted that this kind of opportunity improves student way of thinking. When students give spoken or written answers to others thoughts, their thoughts are constructed and transferred into speech. Student transformation of thoughts into words, and turning back to thoughts to revise them over and over again can support knowledge construction.

The emphasis on using argumentation in scientific inquiry is deeply related to the goal of science literacy determined by the current reform movements (Pinney, 2014). Moreover, the importance of it in implementing inquiry has been the focus of many research studies. Many researchers (Albe, 2008; Chin & Osborne, 2010; Hogan, Nastasi, & Pressley, 2000; Maloney & Simon, 2006; Martin & Hand, 2009; McNeill & Pimentel, 2010) strongly support student generating arguments, explanations, and models as they involve in inquiry investigations. Science argumentation as a core practice of investigating science not only helps understanding of scientific concepts, but also develops conceptions on nature of science and science literacy (Duschl, 2008; Grooms & Walker, 2011; Hand, Yore, Jagger, & Prain, 2010; Jimenez-Aleixandre & Erduran, 2008; Simon, Erduran, & Osborne, 2006). Through argumentation in science inquiry, students learn how to think critically and actively implement appropriate reasoning strategies (Lemke, 1990). Argument-Based Inquiry (ABI) provides students opportunities with understanding of various nature of scientific knowledge and the role of empirical data in scientific practices (Maloney & Simon, 2006).

According to Hand (2008), ABI concerns with how individuals learn cognitively. It is an approach triggering cognitive processes (Hand, Norton-Meier, Staker, & Bintz, 2009) since it provides learners opportunities to communicate and reflect upon what they think through generating claims and evidence to construct new knowledge

(Driver et al., 2000). Several researchers (e.g., Cavagnetto, 2010; Duschl, 2008;) asserted that the ABI does not only provide individuals practicing of cognitive skills but also promotes strong understanding regarding the epistemology of scientific knowledge through dialogical interactions with their teacher and classmates. Similarly, Simon, Erduran and Osborne (2006) asserted that "the teaching of argumentation through the use of appropriate activities and pedagogical strategies is a means of promoting epistemic, cognitive and social goals as well as enhancing students' conceptual understanding of science" (p.236). The significance of ABI in individuals' practices of cognitive and social processes was empirically demonstrated by Kim and Song (2005). The researchers examined the characteristics of peer argumentation in middle school students' scientific inquiry since the empirical research in this area generally focus on completion of practical procedures rather than considering the role of argumentation in scientific inquiry. By examining multiple data source such as video-tapes, student reports, and interviews collected through small group inquiry activities, they observed that the students experienced various cognitive and social processes. Student argumentation in small group inquiry works provided them to experience cognitive strategies such as "questioning, elaboration, clarification, using analogy, hypothesizing, and authorization" (p. 222). The social strategies included practices such as negotiation of ideas, peer suggestions, critiques, and challenges on the content and procedures in inquiry activities. The researchers finally claimed that argumentation provided students to "check and reflect their inquiry" (p. 231) by providing them opportunities to practice various social and cognitive processes.

Additional evidence on why ABI is desirable in science classrooms is about contribution of it on student achievement regardless of individuals' background differences (such as socio-economic status and variety in learning abilities). By addressing the impact of students' socio-economic status on achievements, several researchers (e.g., Caldas & Bankston, 1997; Kan & Tsai, 2004) claimed that family backgrounds on socio-economic conditions have direct or indirect effect on learners' academic achievement. In this manner, Yesildag-Hasancebi and Gunel (2013) conducted a quasi-experimental study with a control and treatment group in a socio-economically disadvantaged school in Turkey and investigated the impact of ABI approach on disadvantaged students' science achievement. While the treatment group was exposed to classrooms facilitating with ABI approach, the control group was not manipulated with any treatment. By comparing the groups on science achievement scores, the researchers observed that although groups did not significantly differ in pre-test scores, students in the treatment group achieved significantly higher scores than those in the control group after the treatment. ABI approach leaded higher achievement for disadvantaged students through improving their skills to generate argument (Yesildag-Hasancebi & Gunel, 2013).

Similarly, Villanueva and Hand (2011) argued for the need to provide learners opportunities with engagement in practices such as asking questions, generating evidence-based claims in order to achieve 'science for all'. The researchers emphasized the role of ABI classrooms on creating evaluative and nonthreatening learning environments for all students but especially for those having learning disabilities. For instance, students with learning disabilities are involved in own knowledge generation through laboratory works, asking questions, proposing methods rather than engaging in simply reading text, which are above their ability levels. These practices in ABI classrooms provide conceptual and procedural understandings to even disadvantaged students those having learning disabilities (Villanueva & Hand, 2011).

Achievement gaps emerged from students' initial differences (e.g., variety in socio-cultural, socio-economic status, or learning abilities) have been targeted by the reform movements in both international and national setting. For instance, the Ministry of Turkish Education initiated a project in 2011 in order to make science accessible for all students especially for those disadvantaged in socio-economic conditions, and learning abilities. Similarly, in the USA, the NRC (2012) expressed that primary need to develop NGSS was emerged from the achievement gaps among various cultures in the nation. As exemplified in above mentioned studies and suggested by current reform movements (e.g., MoNE, 2013; NRC, 2012), ABI practices has key importance in order to achieve science for all students.

2.2 Teacher Roles in the Classroom

A shift in reform movements in education requires significant teacher changes in teaching practices (Killion, 2002). As stated by Corcoran (1995), it was the high expectations of reform efforts to encourage teachers to learn new skills and improve teaching practices. The explicit emphasis of science reforms on creating ABI learning environments in national and international settings required to examine what is expected from teachers to achieve them. The National Science Teacher Association (NSTA) (2014), for instance, determined the required teacher abilities to achieve NGSS such as the followings:

Teachers should:

1. "facilitate appropriate and effective discourse and argumentation with and among students" (p. 5)
2. "maintain a classroom atmosphere that supports and reinforces the attitude of reflection, respect for logical thinking, and consideration of scientifically based alternate explanations" (p. 7)
3. "be aware of the conceptions that students bring to class and the instruction needed to build on and/or modify them" (p. 7).

Although ABI has recently been emphasized in the current reform movements, it has been the topic of investigation in empirical research for many years. One of these research was conducted by Martin and Hand (2009) with the aim of describing teaching actions affecting the implementation of ABI in an elementary science classroom. By examining experienced teacher actions to shift her pedagogic practices in ABI teaching throughout two years of longitudinal study, the researchers modified an instrument called Reformed Teaching Observation Protocol (RTOP) and drew several conclusions on the teaching actions based on this instrument. The RTOP was originally designed to capture reform movements in education in 2002 based on Project 2061: Science for All Americans and National Science Education Standards (Piburn et al., 2000); however, since education reforms has undergone changes so many fast, the researchers made modification based on the observed teaching actions in the context of ABI approach. The modified RTOP tells us about the role of teacher by describing the student's and teacher's involvement in the ABI process. The teacher's roles in ABI classrooms are given in Table 2.1. It is significant to note that although teacher role was determined with specific actions in the table, the deeper understanding into the role requires examining the characteristics of ABI classrooms holistically. This requirement emerges from the role of teacher as an inquirer, guide, or resource person (Martin, 2006) in ABI classrooms. Since there is a shift in the responsibility of learning from the teacher to student (Norton-Meier, Hand, & Ardasheva, 2013), it attracts significance to examine what students are required to do in ABI learning environments in order to enlighten the 'facilitator' role of teachers. As clarified in Table 2.1, teacher role was specifically determined as a guide and listener. Teacher role as a guide has emphasis in science classrooms by using of researchers different labels throughout time such as "fellow investigator" (Lawson, Abraham, & Renner, 1989), "experienced co-learner" (Moscovici & Nelson, 1998), and ''co-inquirer,'' ''guide,'' or ''resource person'' (Martin, 2006). What is meant by 'teacher as listener' is that teacher listens students and acts according to what students said (Piburn et al., 2000). There should be a convergent action of a teacher based on a student utterance. Aside from the aspect of teacher role in the instrument, main criteria of the modified reform teaching are student voice, science argument and questioning.

Table 2.1. Central Components of ABI Classroom and Connections with the Teacher and Student Roles

	Components	Connections
Student Voice	-Instructional strategies respected students' prior knowledge/preconceptions.	-Connections: There is an emphasis on determining student knowledge and building teacher plans based on this knowledge.
	-Focus and direction of lesson determined by ideas from students.	-Connections: Teacher builds or activates students' prior knowledge with some evidence of using it to make instructional decisions.
	-Students communicated their ideas to others	-Focus on learning: Student sharing with argumentation / connections in either small group, group to group or whole group.
		-Connections: Language activities flow naturally throughout the classroom.
		-Science argument: Teacher promotes linkages to big ideas and begins to promote debate on these ideas.
	-High proportion of student talk and a significant amount was student to student.	-Focus on learning: Student sharing with argumentation/connections in either small group, group to group or whole group.
		-Dialogical interaction: Communication effectively varies from teacher to student and from student to student according to the situation.
	-Students' questions and comments determined focus and direction of classroom discourse.	-Connections: Teacher effectively builds or activates student prior knowledge with evidence of using this to make instructional decisions.
		-Dialogical interaction: Teacher is not compelled to give right answer shifting focus to the big idea Teacher uses all levels of questioning, and adjusts levels to individual students.
Teacher Role	-Teacher acted as resource person, supporting, and enhancing student investigations.	Focus on learning: Teacher effectively plans for teacher and student instruction as needed and appropriate.
	-The metaphor "teacher as listener" was very characteristic of this classroom.	Dialogical interaction: Teacher used questions to explore student thinking. Teacher's response to student answers is probing, connects, and extends, questions.

Table 2.1. (Continued)		
	Components	Connections
Science Argument	-Students were actively engaged in thought provoking activities that involved critical assessment of procedures.	Connections: Science activities promote big ideas clearly and extend students learning Connections can be seen from beginning to end and are articulated by students.
	-Students were reflective about their learning.	Science argumentation: Teacher demands connections between question, claims, evidence and reflection.
	-Intellectual rigor, constructive criticism, and the challenging of ideas were valued.	Focus on learning: Student sharing with argumentation/connection in small groups, group to group and whole group with few prompts.
		Science argumentation: Teacher promotes linkage to big ideas and promotes debate on these ideas.
	-Active participation was encouraged and valued.	Science argument: Teacher requires students to link claims and evidence. Teacher scaffolds questions, claims, evidence and reflection. Promotes linkages to big ideas, and promotes debate of these ideas.
	-Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	Science argumentation: Teacher scaffolds questions, claims, evidence and reflection. Promotes reflection to big ideas and promotes debate of these ideas.
Questioning	- Teacher questioning triggered divergent modes of thinking.	Dialogical interaction: Students are asked to explain and challenge each other's responses rather than the teacher passing judgment. Teacher asks many layered questions (i.e. Bloom's Taxonomy). Teacher is not compelled to give "right" answer shifting focus to the big idea.

Source: Martin, A. M. & Hand, B. (2009). Factors affecting the implementation of argument in the elementary science classroom: A longitudinal case study. *Research in Science Education. 39* (1), 17-38.

Teacher's role of guide in ABI classrooms can be explained with increase in student voice, active involvement of students in science argument and scientific investigations, and initiating divergent thinking forms by teacher's use of effective questioning (Piburn et al., 2000).

Among these variables, questioning has core importance to initiate student voice and actively engage them in science investigations (Martin & Hand, 2009). The central significance of teacher questioning to promote high quality ABI environments was testified in a study of Martin and Hand (2009). By analyzing a teacher attempt to shift her pedagogical practices in an ABI classroom, the researchers observed that significant improvements in the teaching practices occurred in teacher questioning and student voice. They observed a teacher in thirteen science lessons recorded over 2 year-period of a professional development program and assessed the quality of each lesson as low, medium and high. When the teacher hit the top at high quality ABI lesson, the shifting indicator of quality was determined as changes in teacher questioning and resulting increase in student voice.

Questions are so connatural to classroom environments (Wilen & Clegg, 1986) that teachers should become professional questioners (Gall, 1984). The significant role of questioning in the nature of classroom environments is not a newly discovered issue. It has been emphasized in the research for more than a century (Bolen, 2009). However, the change in science standards throughout the history has assigned various roles to teachers in questioning over time.

2.3 Teacher Questioning

The role of teacher questioning in traditional teaching methods has been consistently determined to evaluate student knowledge. In traditional classrooms, the questions usually look for specific scientific idea and require students to recall their prior knowledge or to try to find what teacher wants to hear (Chin, 2007). The role of teacher as an authority of knowledge involves students to accept what teacher says without negotiation of the ideas (van Zee & Minstrell, 1997b). As a result, student challenges of teacher questions are perceived as a threat (Baird & Northfield, 1992). The questions do not serve to the purpose of student expressing of own thoughts (Chin, 2007). Similarly, Baron (1984) cautioned that traditional classrooms focus on repetition and factual learning; thus, could not achieve to reinforce higher level student thinking.

However, teacher questions should serve to various cognitive functions in a classroom discourse. Science educators usually adopted “a cognitive functional perspective on oral questioning, viewing teacher questions essentially as communicative devices for promoting higher-level scientific thinking among students” (Oliveira, 2009, p. 424). Chin (2007) argued that effective teacher questions should provide opportunities to experience higher-level scientific thinking among students. Similarly, Koufetta-Menicou and Scaife (2000) cautioned that teacher questions should encourage students to involve in higher level thinking rather than simply recalling information in inquiry-oriented science lessons. In addition to promoting higher-level thinking, teacher questioning has also involve in several other cognitive operations, which include assisting students to solve experimental problems and to scaffold and intensify knowledge acquired from the experiments (Wells, 1993), structuring discursive and analytic attitudes as students involving in inquiry activities (Crawford, 2000), initiating higher-levels of reasoning and quality explanations (Hogan, Nastasi, & Pressley, 2000).

The active role of questioning in initiating student cognitive functions has been the topic of investigation in empirical research for many decades. It has been consistently emphasized in the literature that effective teacher questioning depends on teacher’s ability to ask questions that initiates higher level thinking (Dantonio & Beisenherz, 2001). Educators mostly agree that teacher questions should serve improvement of various thinking skills rather than engaging students in learning of factual information (Aschner, 1961; Carner, 1963; Hunkins, 1966). Many researchers (Gallagher & Aschner, 1963; King, 1995; Wease, 1976; Wilen & Clegg, 1986) have reviewed the literature on questioning and thinking in order to identify that whether one can directly correlate the level of teacher questions and level of student thinking processes. Gallagher and Aschner (1963), King (1995), Wease (1976), and Wilen and Clegg (1986) all noted a direct correlation between these two variables. In this sense, researchers attempted to examine cognitive characteristics of teacher questions and student responses (Gall, 1970).

In the 1950s and 1960s questioning research focused on classifying teacher questions into categories based on cognitive demand placed on the student. This cognitive demand was mostly explained with various thinking processes. The questioning has always central focus on all thinking strategies, including creative thinking, analytical thinking, critical thinking, decision-making, and problem solving (Walsh & Sattes, 1991). Some notable categorizations were Bloom's (Bloom, Englehart, Furst, Hill, & Kratwhol, 1956), Schreiber's (1967), and Aschner's (1961) taxonomies. These categorizations enable researchers to examine issues such as type of questions (Pfeiffer & Davis, 1965) by quantifying the cognitive demand of questions (Gall, 1970). Bloom and his colleagues (1956) argued that this classification system (Bloom's taxonomy) provides researches operational definitions of hierarchical thinking processes that can be applied to observe or assess question structures. Each of these taxonomies maintained that by determining various levels of thought, teachers could easily pose questions at particular levels of thinking. This is explained by Dillon (1982) as a cognitive correspondence, which refers to match between level of question and level of the response. The rationale of the research examining cognitive correspondence has emerged from the direct role of questioning in initiating cognitive functions in response.

2.3.1 Question Classification Systems

Most of the question classification systems in education literature were developed based on various cognitive functions that the response requires (Gall, 1970). Researchers assume that level of questions can be categorized independent from the subjects and contexts (Yang, 2006). According to Storey (2004), there are three main themes to classify questions in research literature. These are cognitive hierarchy (e.g., knowledge to evaluation), sophistication (higher or lower-level questions), and structure (open-ended or close-ended).

2.3.1.1 Cognitive Hierarchy

Cognitive hierarchy comprises a set of cognitive demands in different complexities (Bloom et al., 1956; Ornstein, 1988). The most common scheme used to categorize cognitive level of teacher questions in literature is Bloom's taxonomy. In this classification system, the researcher defined six categories according to cognitive demand of the questions. The categories, which are knowledge, comprehension, application, analysis, synthesis, and evaluation, are ranked from simplest to complex one based on the type of cognitive demand of the question. Evaluation is at the highest complexity in the hierarchy and demands the highest level of cognitive operations. Several researchers (e.g., Adams, 1964; Aschner, 1961; Carner, 1963) were then developed question classification taxonomies with the inspiration of Bloom's taxonomy. The representative question classification systems are provided in Table 2.2.

Several systems in this cognitive hierarchy, such as Bloom's, Gallagher's, and Carner's, have limited number of categories to classify questions (Gall, 1970). If researchers are interested in a detailed description on question types, these systems are not appropriate to apply (Gall, 1970). Several critiques were made on Bloom's taxonomy by Sugrue (2002) that the taxonomy is invalid, unreliable and impractical. Although it is about 50 years old, several categories (e.g., analysis, synthesis and evaluation) have not been supported by any research to be in the higher degree of cognitive processes (Sugrue, 2002). Moreover, there is not specific distinction between either of the two lowest categories (knowledge or comprehension) or between four highest levels (application, analysis, synthesis, and evaluation). The questions can be labeled with different codes by different researchers. Sugrue criticized it stating, the categories above *knowledge* level was determined as higher order skills, which in turn, reduce the taxonomy to two levels.

Table 2.2. Representative Question Classification Systems

Author	Classification				
	Recall	Analytic Thinking	Creative Thinking	Evaluative thinking	Other
Adlibris (1964)	Memory	Ratiocinative (logical	-	Evaluative	Associative, clarifying, neutral
Aschner (1961)	Remembering	Reasoning	Creative thinking	Evaluating	-
Bloom (1956)	Knowledge	Analysis	Synthesis	Evaluation	Comprehension, [illegible]
Carner (1963)	Concrete	Abstract	Creative	-	-
Clements (1964)	Past Experience, Process Recall	-	Planning	Product Judgment	Present experience, rule, opening, identification, suggestion, order, acceptance
Guszak (1967)	Recognition,	Explanation	Conjecture	Evaluation	Translation
Pate & Bremer (1967)	Simple recall of one item, recall choice of multiple-items	Principle involved, concept analysis	Divergence	-	Determination of skills abilities (demonstrate), skills demonstration (verbal), example-singular, examples-multiple
Schreiber (1967)	Recall of Facts, arranging facts in sequential order	Making comparisons, identifying supporting facts, drawing conclusions	Speculating own outcomes	Identifying main part & important parts, stating moral judgment based on personal experience, evaluating quality of source material, evaluating adequacy of data	Describing situations, defining & clarifying information, using globes, using maps, uncovering information & raising questions for study

Further limitations were drawn by Krietzer and Madaus (1994) on the practical use of the taxonomy since for instance, *knowledge* category may involve individuals in more complex demands than analysis or synthesis categories. Moreover, evaluation cannot be more complex than synthesis since synthesis requires making evaluations.

As seen in the representative question classification systems in Table 2.2, the lowest level of cognitive operations were categorized as recalling information, and the complexity increases with various thinking processes, which are analytic thinking, creative thinking and evaluative thinking (Gall, 1970). Higher order cognitive skills were defined as individual involvement in higher order thinking skills. Several researchers also provided critiques on the underlying the philosophy of these taxonomies. Amer (2006) indicated that Bloom's taxonomy do not involve learner-centered paradigms into its structure. For instance, constructivism assumes that students must discover, construct and negotiate knowledge on their own. This requires individuals to make connections between two or more elements in various domains (Amer, 2006). Furst (1994) provided several reflections on Bloom's taxonomy and reported that the cognitive processes are constructed on a single dimension, from basic to complex skills. This one dimension aspect does not require individual's to make relations in various domains. As Anderson and his colleagues (2001) reported that the taxonomy requires a "mastery of a more complex category required prior mastery of all less complex categories below it" (p. 309).

Several cognitive physiologists revised the Bloom's taxonomy by taking into account above mentioned critiques. One of the considerable revisions was made by Anderson and his colleagues (2001). The most notable revisions of these researchers are "the move from *one dimension* to *two dimensions*" in instructional objectives and addition of meta-cognitive knowledge category (Amer, 2006, p. 218). Although the revision of Anderson and his colleagues has overcome several limitations of the original taxonomy (Amer, 2006), it still lacks complex operations such as making argumentation, induction, and deduction. These complex operations were claimed by Grimberg & Hand (2009) to be three dimensional objectives and to correspond to high-level practices as suggested by science reform movements. The detailed description regarding the complexity of these operations is given later in the chapter.

Bloom's taxonomy was used for illustrative purposes. The notion of the cognitive hierarchy classification system was addressed by using Bloom's taxonomy since it has the most common usage in education literature.

2.3.1.2 Sophistication

Questions are generally classified as either lower level or higher level questions (Ornstein, 1988; Wilen, 1991; Winne, 1979). This system make categorizations as low or high based on the cognitive level of student responses. For instance, when teacher question seems to involve student in a low level cognitive response, the question is labeled as low level. Low level questions require for specific recall of knowledge (Orenstein, 1987; Winne, 1979) and place few cognitive demands on students (Graesser & Person, 1994). Lower level questions give the impression to students that the question has only one right answer (Hamm & Perry, 2002). This impression does not encourage students to reflect in various ways rather simply provide them to recall the memorization of the information. In literature, lower level questions have been defined in various labels; text-based (Scardamalia & Bereiter, 1992), knowledge and comprehension (Bloom, 1956; Gall, Dunning, & Weathersby, 1971), convergent (Pate & Bremer, 1967) factual information, assimilating knowledge (Schreiber, 1967), short answer or close-ended (Graesser & Peterson, 1994).

Higher level questions, on the other hand, require high-level cognitive functions in response and permit longer range of responses than lower level questions. High-level question type is defined in education literature as analysis, synthesis, and evaluation (Bloom et al., 1956; Gall, Dunning, & Wheathersby, 1971), formulating opinion and interpreting information (Schreiber 1967), divergent (Pate & Bremer, 1967), and open-ended or long answer (Graesser & Person, 1994). Research mostly found that an effective teacher questioning was related to teacher's ability to ask questions promoting higher level cognitive operations (Dantonio & Beisenherz, 2001). In the literature, while there is a consensus on what constitutes a lower level question, it is more complex to identify what type of question should be categorized as high-level. This conflict may emerge from the various definitions of high-level cognitive skills in education literature. In other words, although many researchers agreed that high-level questions involve in high-level cognitive practices in the response, it is controversial what constitutes high-level cognitive practices.

One of the attempts to describe higher level student cognitive practices was made by Gall and Rhody (1987) by stating, "Higher cognitive questions are usually defined as questions that required students use such thought process as analyzing, problem solving, predicting, and evaluating" (p. 32). Grimberg and Hand (2009) claimed that student high-level cognitive operations should involve practice of induction/generalization, deduction, investigation design and argumentation. The researchers developed a coding pathway in order to categorize student cognitive operations in the written text. They revealed 11 cognitive operations by examining documents of students those performing laboratory activities in ABI classrooms. These operations were classified into three complexity levels, from low to high. While low cognitive operations involve observations, measurements, and comparisons, medium-level involves analogies, clarifications using questions or statements, claims, cause/effect relations. The researchers discussed the rationale behind these three categorizations that the number of domains in the observed operations or complexity of each. The researchers further claimed that a high cognitive operation should encourage students to practice abstraction (Grimberg & Hand, 2009). One of the strength sides of these categories is that they were emerged in a standards-based classroom. Similarly, according to Chesebro and McCroskey (2001) student cognitive processes happen in three levels, which are low, medium and high. The lower level cognitive process requires calling for specific knowledge. Medium-level as the second phase involves students making hypothesis, generalizations, discovering reasons. Lastly, the high-level process is where students analyze, synthesize and judge knowledge and make evidence-based predictions.

The present study adopted the categories of high-level cognitive practices determined by Grimberg and Hand (2009). The rationale behind adoption of these categories is provided in instrumentation section of the study.

2.3.1.3 Structure

The questions can be also classified considering whether they are close-ended or open-ended. While close-ended questions are defined as those require specific and very predictable answer, open-ended type cannot be answered with a specific and concrete knowledge (Graesser & Person, 1994). Open-ended questions involve students in long or extended answers with usually requiring a sentence instead of a word or phrase (Graesser & Person, 1994). The most common classification system in this category was developed by Graesser and Person (1994). The researchers developed Taxonomy of Question Types (TQT) by categorizing questions as close-ended, open-ended as well as management. While close-ended and open-ended questions adopted the above given definitions, management questions are defined by the researchers as those applied to manage student directions while they are making experiments, or completing assignments. Similar to classification systems discussed above the taxonomy of questions type also based on various cognitive levels. While close-ended questions are defined as lower cognitive level questions, open-ended type is referred as higher level. Management questions are those do not fall in any cognitive categories. One of the advantages of TQT is that what is exactly meant by each question type was elaborated with sub-categories. For instance, close-ended questions included five sub-categories, which are verification, disjunctive, concept completion, feature specification, and quantification questions. Similar sub-categorizations were also developed for open-ended and management question types. As suggested by Gall (1970), this provides researchers to make more detailed descriptions on the question types.

Although Erdogan (2006) considered that the TQT meets nearly all inquiries adequately, some criticized it that higher level questions in the taxonomy do not properly target high-level of cognitive operations in response. The details of this will be discussed in the instrumentation section of the next chapter.

2.3.2 Types of Questions Used in the Classrooms

Chin (2007) elicited the rationale on examining the types of questions by stating, “The kinds of questions that teachers ask and the way teachers ask these questions can, to some extent, influence type of cognitive processes that students engage in as they grapple with the process of constructing scientific knowledge” (p. 817). Similarly, Pate and Bremer (1967) gave some insight into the researchers’ attempt to examine teacher question types by claiming that “The teacher’s effectiveness in questioning depends on an awareness of various purposes that questions may serve and an awareness of different types of questions for achieving these purposes” (p. 422). Accordingly, one of the considerations in effective teacher questioning should be examining teacher use of question types.

The type of questions asked by teachers has been investigated over a century (Bolen, 2009). A brief historical reflection provides insight into the teacher use of question types throughout time. One of the earliest studies was conducted at the beginning of the 1910s. Steven (1912) attempted to examine variety in teacher question types and to describe characteristics of an effective question since teacher training programs in this term had gave little emphasis to teacher questioning. She studied with high school teachers teaching in various grade levels and different subject areas, and found that approximately 66 percent of teacher questions required recall of textbook information. The researcher observed that teachers ask more questions than students and generally, the teacher questions are not asked spontaneously with a motivation to really want to know something. She suggested that questions should be inquisitive in nature by structuring it based on student experiences. This finding is correlative with the role of questioning in inquiry-oriented classrooms, which indicates that teachers should not bring a series of pre-determined questions into the classroom (Chin, 2007). Instead, the questioning should be constructed flexible by considering student responses.

Two decades later, Haynes (1935) observed that approximately 70 percent of teacher questions those asked to 12-13 years old students demanded for factual answers, while only 17 percent encouraged them to think. By designing an instructional program to develop teacher questioning skills, Schreiber (1967) observed discourse interactions in a total of 14 fifth grade classrooms before and after the program. The researcher found that while at least 50% of the questions required "recall of facts and arranging facts in sequential order" before the program, they significantly decreased after the program. The number of high-level questions focusing such as on comparisons, identifying, describing situations and clarifying information increased. At the junior high school level, Hoetker (1967) examined nine English teacher's varieties in question types during recitation lessons and discovered that more than 80% of the questions required memorization in responses. Similar results were obtained by Davis and Tisley (1967) while the researchers observed questioning types of student teachers. At least 50 percent of questions asked by student teachers were required students to give specific information. Additional evidence on the teacher's use of factual questions was provided by Bellack, Kliebard, Hyman, and Smith (1966). The researchers studied with fifteen eleventh-grade students in social studies classrooms and observed four lesson periods of each. Hoetker and Ahlbrand (1969) analyzed the data of Bellack and his colleagues and found that 81 percent of teacher questions required students to recall of factual information.

Gall and his colleagues (1971) found that there is no change on the type of questions emphasized in the classrooms for about 50 years. While nearly 60 percent of teacher questions expects student to recall of facts, 20 percent requires student thinking and 20 percent is procedural questions. Other writers supported the claim of Gall in 1980s with slightly different percentages. For instance, by investigating questioning in primary and middle school classrooms, Galton, Simon and Croll (1980) observed that teachers spent approximately 12 percent of their class times to ask questions.

While nearly 47 percent of these questions were devoted to procedural and management purpose, 29 percent was factual recall and 23 percent focused on student ideas. Similar results were obtained by Kerry (1989) in analyzing a total of 213 class hours of teachers teaching at various fields. The researcher found that while most of the questions were procedural, only 4 percent required students to practice higher order of thinking.

Similar to research findings until 1990s, it has been consistently observed in the last three decades that teachers mostly apply lower-level, factual questions (Dantonio & Beisenherz, 2001; Hamm & Perry, 2002; Newton & Newton, 2000; Yip, 2004). Most teacher questions engage students in short-answers that require memorization of factual information, while questions that demand for higher order cognitive skills have a very small percentage (Graesser & Person, 1994).

Yip (2004) observed questioning skills of 14 biology teachers teaching at high schools (grade 9-11). The researcher applied to a categorization system slightly different from the frequently used taxonomies. Questions in the study were categorized as low-level, high-level, and conceptual-change questions. Low-level questions were determined as those requiring recall of information and explanation of a phenomenon or process. While higher order questions are associated with the several objectives of Bloom’s taxonomy (analysis, evaluation, and synthesis), conceptual change questions were determined as those eliciting preconceptions, challenging and extending student ideas and requiring students to apply newly learned materials to other situations. The researcher found that 35.1% of questions were at low-level, 25.4% were high-level and 27.4% were conceptual-change questions. By specifically focusing on questioning skills to promote conceptual change, the researcher observed that only two teachers among fourteen were able to ask conceptual change questions to facilitate learning.

By investigating questioning in primary classes in south west of England, Brown and Wragg (1993) found slightly different results from above discussed studies. The researchers observed that questions asked by teachers comprised 10% of classroom interaction. By analyzing over 1,000 questions, 92% of them were found to be management questions, while just a few open-ended or more demanding questions involved in the lessons. The researchers suggested that:

> Teachers do not necessarily prepare such questions, but somehow expect them to arise spontaneously. It may be that if we want to ask questions to get children to think, then we've got to think ourselves about the questions we are going to ask them (p. 14).

Chin (2006) examined teacher questioning strategies used in initiating productive thinking in science classrooms. Instead of looking at the type of questions whether to be open-ended or close-ended, the researcher qualitatively described the nature of teacher questions and the purposes that they serve. By observing a total of 36 lessons of six science teachers teaching at seventh grade classrooms, she suggested specific questioning strategies used by the teachers to construct student thinking and scientific knowledge. These strategies were grouped by the researcher into four categories namely, "Socratic questioning, verbal jigsaw, semantic tapestry, and framing". Socratic questioning aims to initiate student thinking by "probing, extending, and elaborating on students' ideas" (p. 824). Verbal jigsaw questioning required students to involve in factual information and was used especially when the subject matter included various scientific terms to be studied. Students were encouraged to practice multi-modal thinking (i.e., verbal, visual, symbolic, mathematical) by semantic tapestry strategy in which the teacher questions focused on abstract concepts and ideas rather than specific scientific terms. Lastly, the researcher suggested a framing strategy in that the questions served to encourage students in making relationships between a question and the information that the response seeks. In this strategy, the teacher questions aimed to construct a problem, issue or scenario in order to help students to see the main focus of the question for instance "Imagine you're an oxygen atom. You start moving, going through the nose. What is the first path taken?" (p. 834). By observing various questioning strategies in the science classrooms, the researcher suggested that these strategies can help teachers to improve their repertoire in questioning practices.

As previously discussed in the present study, teacher questions serve to different purposes in classrooms facilitating with different approaches. For instance, as Chin (2007) highlighted that the primary aim of the teacher questions in a traditional classroom setting is to evaluate student knowledge. Students in traditional classrooms are challenged with their factual information instead of practicing various skills such as creative thinking, evaluative thinking or reasoning. Thus, if a researcher attempts to observe teacher questioning behavior in a traditional classroom, it is more likely to found that teachers usually use factual questions since this type of questions aims student practices of factual information as suggested by traditional paradigms. In this manner, several researchers attempted to examine types of teacher questions in classrooms facilitating with approaches suggested by the science reform movements.

One of these studies was conducted by Cikmaz (2014) in order to examine the differences in the quality of teacher questions in low and high implementation level practices of ABI. The researcher studied with two middle school teachers that participated in a longitudinal study in Turkey. While high-level quality implementations reflected practices as suggested by reform movements in Turkey, the low level implementation referred to more traditional teaching practice. Low and high-level implementations were determined based on student writing scores that acquired from classroom reports while students were engaged in ABI practices. The researcher observed that the high-level teacher asked more questions those in high cognitive level than the low level teacher. The low and high cognitive level questions were determined based on Bloom’s taxonomy. Although the teachers asked questions in knowledge, comprehension, and analysis levels, they did not apply any question in application, synthesis, and evaluation levels of Bloom’s taxonomy. In other words, Cikmaz could not find any question in application, synthesis, and evaluation levels during his coding of low and high quality classrooms. Therefore, he addressed analysis step as high cognitive level question.

As opposed to results of Cikmaz (2014), Gunel, Kingir and Geban (2012) found that teachers in their different implementation levels of ABI used questions at various levels of Bloom's taxonomy. The researchers investigated questioning behaviors of three teachers; two of which were middle school science teachers (Teacher 1 and Teacher 2), while one was a research assistant conducting ABI laboratory activities in a university in Turkey (Teacher 3). Each participant facilitated ABI implementations in various quality levels (i.e., low, medium, or high). While Teacher 1 facilitated low quality implementation of ABI, the quality level of implementations increased with Teacher 2 and Teacher 3. The researchers observed that although each teacher used questions in various cognitive levels of Bloom's taxonomy, Teacher 2 and Teacher 3 asked more questions in high cognitive level than Teacher 1. When classroom implementation went beyond from traditional teaching to more ABI oriented, the teachers asked more high cognitive level questions.

Gunel, Kingir and Geban (2012) further investigated the quality of follow-up questions in different implementation levels of ABI. The researchers explained the reason behind this investigation with Gall's (1970) assertion that question types should not be addressed as isolated from each other. When teachers ask high-level questions, students may involve in high cognitive level skills; however the reason behind student practice of these skills might come from memorized information. In this regard, follow-up questions attract importance since it provides teachers opportunities to examine rationale behind students' initial response and continue to challenge student thinking. By examining the characteristics of follow-up questions asked by the three teachers, researchers observed that while the teacher facilitating with low-implementation quality asked follow-up questions in an attempt to evaluate student initial response as 'right' or 'wrong', follow-up questions asked by others having higher implementation qualities served to facilitate student talk. Additionally, the researchers found a positive relationship between the level of teacher questions and negotiations occurred in the classrooms. "The higher the level of questions asked, the more the negotiations were occurring in the classrooms" (317). Follow-up questions were also found to be effective in the sustaining of the classroom negotiation.

Erdogan and Campbell (2008) described teacher question types in different quality levels of constructivist teaching practices. The constructivist teaching practices in the researchers' study referred to student-centered strategies such as discussion, brainstorming, experiments, demonstrations, and student presentations. The researchers examined teacher question types in low and high quality implementations of constructivist teaching practices in order to provide insight into the difference of teacher questions types used in the classrooms. While teachers in high quality classroom were referred as expert, who achieved practical understanding of constructivist teaching, those in low quality level classrooms were called as competent, who adopt more traditional teaching methods compared to expert teachers. The different quality implementations were achieved in one year professional development program. The researchers studied with fourteen elementary school science teachers and recorded a classroom video of each. First, they determined the quality level of constructivist practice. Two tapes with lowest scores and two tapes with the highest scores were used to group classrooms as low and high practices and then, teacher question types were categorized as close-ended, open-ended and management questions based on taxonomy of question types developed by Graesser and Person (1994). Analysis of the data revealed that expert teachers asked significantly more close-ended and open-ended questions. The management questions did not significantly differ between two groups. Although the nature of low level questions are generally associated with traditional learning environments (Hargreaves, 1984; Roth, 1996), the researchers found that teachers in high-level practices asked more-close ended questions than those in low level but they were not as dominant as the open-ended questions. Additionally, the researchers reported that teachers facilitating high-level practices asked 3 times more questions than those in low level. They related the increased number of teacher questions to active role of teacher in constructivist learning environments.

Martin and Hand (2009) argued for the need of the decrease in the total number of teacher questions in order to shift the focus of the lesson from teacher-oriented to more open discursive practices. While examining questioning of a science teacher in ABI learning environment over a course of two years professional development program, Martin and Hand (2009) noted that this significant decrease was resulted from the decrease of factual recall and yes/no type questions of teachers. By studying with K-12 classroom samples in the United States, Tobin (1987) found similar results that when the number of teacher question decreased, the amount of student talks increased in the classrooms. While it is controversial whether total number of questions asked by teachers increases or decreases in high quality classroom questioning, Gadamer (1993) pointed out that number of questions asked by teacher do not much matter. The researcher further cautioned that a question focusing on a particular thinking can be more effective than a hundred questions requiring only the recall of facts.

2.3.3 Effect of Teacher Question Types on Student Learning

Although higher level questions are noted as to be categorically better than lower level questions in theory, there are many research examining the effect of type of questions in relation to student learning outcomes in practice. Much of the research focused on comparing two notable learning outcomes: teacher questioning in relation to student achievement (Redfield & Rouseau, 1981; Winne, 1979); and teacher questioning in relation to level of student responses (Dillon, 1982; Lamb, 1976; Rosenshine, 1976). Dunkin and Biddle (1974), and Rosenshine (1971) reviewed the research that conducted mostly in 1960s, and revealed that there is not a specific trend in the relationship between cognitive level of teacher question and student learning. However, Heath and Nielson (1974) provided many criticisms on the methodological approaches of these studies. Rosenshine (1976) reviewed three large correlational studies conducted at the beginning of 1970s. The researcher reported that students learn better when teacher questions "tend to be narrow rather than guess the answer, and the teacher immediately reinforces an answer as right or wrong" (p.

365). Another review was made by Winne (1979) on a total of 18 experiments examining the effect of low or higher cognitive questions on student learning. The researcher concluded "whether teachers use predominantly higher cognitive questions or predominantly fact questions make little difference in student achievement" (p. 43). Although these reviews do not favor higher cognitive questions to promote student learning, several researchers claimed that it is more effective to apply higher level questions to initiate learning. In this sense, Andre (1979) observed that higher cognitive questions promote better textbook learning than fact-based questions. In a more recent study, Lapadat (2000) examined the classroom interactions and the way of knowledge construction in a sixth grade and seventh grade elementary school classrooms for one semester. The researcher found that an open-ended question, which is not predictable and permits a long range of response, was better to scaffold conceptual changes.

Above discussed research reviews handled student learning as mostly considering student achievement; however, most of them did not clearly identified how achievement was measured. Gall (1984) claimed that "Teachers' questions that require students to think independently and those that require recall of information are both useful but serve different purposes. The challenge for teachers is to use each type to its best advantage" (p. 41). Considering the point of Gall, it is significant to review the research considering how research aims achievement. If the student achievement is assessed with tests requiring factual information, it may be not surprising to attain the result that low-level teacher questions initiate much student learning than high-level questions. In this sense, various studies were conducted to observe direct effect of high-level question on student level of high-level thinking.

The research examining the impact of high cognitive level questions on initiating high-level thinking found contradictory findings (Redfield & Rousseau, 1981; Winne, 1979). While several researchers observed direct correlation, several have shown that merely asking a high-level question does not ensure that students' response will be in high-level thinking.

Hassler (1980) investigated the relation between high-level teacher questions and high-level student responses by conducting an experimental research design. The researcher studied with twenty elementary school teachers and their third and fourth grade classes. While the treatment group received an intensive training on questioning, the control group was not manipulated with any treatment. By comparing the groups, the researcher observed that teachers in treatment groups significantly increased higher cognitive level questions. Students in the treatment group correspondingly revealed higher level of thinking than those in the control group. While high-level questions were determined as categories of comprehension, application, analysis, synthesis, according to Bloom's taxonomy of objectives, higher level responses were coded based on the categories, which are explaining, interpreting, defining, opining, and justifying. Similar conclusions were drawn by Lamb (1976) and Rosenshine (1976) by indicating that higher-level questions in fact initiate higher-level student responses.

Similar results were found by Bolen (2009) by investigating the effect of limited professional development program on teacher questioning and learner responses in elementary school setting. Limited professional development in the study referred to "an hour long professional development session on effective classroom questioning" (p. 63) implemented three times over 9 weeks period. The researcher conducted a quasi-experimental quantitative approach with eleven teachers, four of which are at kindergarten, four first grade teachers, and three second grade teachers and a total of 200 students in these classes. Teacher questions and learner responses were coded in both control and treatment group into the categories of "lower-conceptual, higher conceptual, higher-inferential, and higher cognitive" (p. 43). While lower conceptual questions are determined as factual questions, high-level questions are those require student higher order thinking skills. The findings revealed an increase in the number of teacher high-level questions and student high-level responses in treatment group. Only small percentage of improvement was observed in control group classrooms. The researcher claimed that limited professional development program increased teacher question quality as well student response level which is a key factor to increase “critical thinking in students; therefore, helping them to become lifelong, democratic decision-makers” (p. 101). Bolen (2009) further cautioned that research examining teacher questions and learner responses has never been conducted before in the context of professional development.

In an attempt to improve teacher questioning through an inquiry-based professional development program, Oliveira (2009) conducted a study with three elementary teachers. The teachers’ questioning and effect of it on student learning was examined before and after the longitudinal inquiry-based program. The researcher applied to a slightly different categorization in question types. This categorization included teacher-centered and student-centered questioning. Teacher-centered question types included display questions and comprehension checks, which require very short student responses and initiate lower-level thinking (knowledge level of Bloom’s taxonomy). Student-centered questions included the types of referential, clarification, and confirmation checks in which students are required to articulate own ideas, or clarify previous statements. These types require long answers and initiate higher-level thinking (comprehension level of Bloom’s taxonomy). By comparing teacher question types before and after the professional development program, Oliveira reported that whereas 51% of the questions were teacher-centered before the program, it decreased to 31% after it. Teacher training in inquiry-based teaching resulted in the increase of student-centered questioning from 49% to 69%. The increase in student-centered questioning, in turn, “prompted longer and more articulated student responses, promoted higher-level student thinking, positioned students as complementary experts, prompted students to provide tentative responses, and encouraged students to conduct authentic investigations” (Oliveira, 2009, p. 422).

Katherine, McNeill and Pimentel (2009) analyzed the role of teacher questioning in student discourse practices. The researchers observed the classrooms of three teachers teaching at high school grade levels and found a significant relationship between teacher questioning techniques and the argumentation discourse in the science classrooms. The teachers applied open-ended and close-ended question types at various proportions in their classroom practices. However, the classroom practice in which students were usually exposed to open-ended question types promoted better student talk and argumentation discourse. The researchers indicated a positive relationship between the percentage of open-ended question types and student practices of reasoning, using evidence to support claims and dialogical interactions with their peers, Additionally, open-ended questions in these classrooms had potential to encourage students "to consider multiple views, reflect on their thinking and reflect on the thinking of their classmates" (p. 203).

In a more recent study, Kawalkar and Vijapurkar (2013) investigated the role of teacher questioning in both traditional and inquiry classrooms. The researchers observed three classroom practices of four science teachers with a total of twelve practices. While two of these teachers had at least 10 years of teaching experience in inquiry, the others taught in traditional way. The researchers examined the impact of questioning on student learning by comparing the outcomes in traditional and inquiry practices. They observed that traditional teachers asked much more questions than inquiry teachers; however, questions in the traditional setting were mostly asked with the aim of evaluating what students already knew. Questions in inquiry classrooms, on the other hand, aimed to trigger student thinking and to encourage all students to participate in discussions, which in turn, provided them opportunities to construct conceptual comprehension. The nature of the questions in inquiry classrooms moved away from "eliciting, diagnosing and probing students' ideas to refining them and guiding the entire class towards accepted scientific knowledge" (p. 2019). The questions had roles in not only initiating discussion but also guiding it. This nature of questioning in inquiry-oriented science classrooms resulted in higher-level student thinking and provided teachers opportunities to bring out and deal with student initial conceptions.

Several researchers (e.g., Dillon, 1982; Harrop & Swinson, 2003; Mills, Rice, Berliner, & Rousseau, 1980), on the other hand, discovered that more than half of the student answers were in lower level even when teacher asked a higher level question. Similar evidence was provided by Dillon (1982) by stating, “Ask a higher-level question, get any level answer” (p. 549). Harrop and Swinson (2003) investigated teacher question types and learner responses in 10 infant, 10 junior high, and 10 secondary school classrooms. The researchers revealed that in all of the grade levels, students usually gave short answers regardless of teacher question types.

It may not be necessarily required to use higher level questions more frequently than lower level ones. Goodwin, Sharp, Cloutier and Diamond (1983) argued that it is important to use systematic and purposeful questioning techniques consisting of both higher and lower level questions together. In this sense, Konya (1972) provided evidence that increase frequency in higher-level questions do not necessarily involve in much high-level response. By studying with two junior high school teachers in their social studies classrooms, the researcher grouped students based on teacher question types that they exposed. In the first group, students were exposed to 65% high-level questions; the second group students were required to answer 50% high-level questions; and students in the third group were required to answer 45% high-level questions. It was observed that students’ high-level response rate is the highest in the second group, who were exposed to equal number of high and low level questions.

Several educators believe that in order to promote higher level thinking, students need to be faced first with factual questions and then higher level ones (Gall, 1970). Teachers should give a direction to discussion first by asking recall questions and then should manipulate ideas with higher cognitive questions (Taba, 1966). Gall (1970), on the other hand, discussed the reason behind asking high-level questions and getting low level answers that it can be related with ineffective question classification systems. Many of the question classification systems (provided above in Table 2.2) were constructed based on investigation of teacher question types which actually observed in a classroom rather than considering the types of questions which teacher should use (Gall, 1970). The researcher further indicated that the question types undoubtedly have significance to be examined; however, they should not be considered as isolated from each other. The research should give more emphasis to look for question sequences (Gall, 1970). The question sequences either involve in multiple question chains, or in question-response sequences. While multiple questions occur when teachers ask a series of questions, which were not interrupted by students, question-response sequence involves examining teacher questions, student responses and teacher reaction to the response (Fink, 1987). The question-response sequence requires focusing on discourse patterns in the classrooms.

2.3.4 Discourse Patterns in the Classrooms

Although the focus of research regarding classroom questioning is mostly on cognitive level of teacher questions (Cotton, 2001), it is also significant to examine classroom discourse patterns to gain insight how to initiate higher order thinking skills (Gall, 1970). The findings commonly revealed two patterns in classroom questioning. One of the predominant one is Initiate-Response-Evaluate pattern (Dillon, 1988; Lemke, 1990). This pattern involves in teacher asking of questions to initiate an interaction, student answering the question and teacher evaluation of the response. The initial question generally occurs in factual or close-ended type. Student gives pre-determined answer to question and teacher confirms corrects answers or corrects the wrong ones. This pattern represents the discourse structure of traditional classrooms (Chin, 2007). The secondly emphasized questioning pattern is Initiate-Response-Feedback-Response-Feedback (IRFRF) structure (Mortimer & Scott, 2003). The IRFRF chain is differed from the IRE structure in a way that student further responses to teacher evaluation or feedback and teacher makes another comment in order to encourage students to continue to discourse or to ask for clarification. This pattern of discourse provides opportunities to structure conversation based on student ideas while exploring them. The characteristics of teacher questioning types and patterns in traditional and inquiry-oriented/constructivist learning environments along with the purpose of each, which was discussed above in the chapter, was summarized by Chin (2007) in Table 2.3.

Examining teacher questioning patterns, Roth (1996) and Mehan (1979) claimed that teachers mostly apply IRE questioning structure. This sequence continues until the teacher gets the desired answer, despite the deterioration of the quality of questioning and interaction (Mehan, 1979). In order for teachers to avoid poor questioning patterns, they need to consider that the questions are distributed throughout classroom time (Goodwin et al., 1983; Morgan & Saxton, 1991). Particularly, teachers need to pay attention to provide some wait time between any two questions. Wait time generally refers to "deliberate silence" (Dillon, 1988, p. 162) between a teacher question and student answer. Otherwise, teacher will involve in asking multiple string questions in which questions are posed without student interruption it.

Multiple string questions are associated with teacher use of short wait time by Fink (1987). The researcher discussed that when a teacher question is not immediately responded by students, teacher asks another questions until gets any response because of the perception that initial question failed. White and Lightbrown (1984) investigated multiple questioning phenomena and discovered that when students did not provide any response to a question immediately, the teacher asked almost nine repetitive questions, which rephrase the initial one.

Table 2.3. Comparison of Teacher Questioning in Traditional and Constructivist Teaching

	Traditional	Constructivist/Inquiry
Purpose of questioning	Evaluate what students know	Elicit what students think, encourage them to elaborate on their thinking, and help them construct conceptual knowledge
Structure of questioning sequence	IRE (teacher-student-teacher)	IRFRF chain Reflective toss (student-teacher-student)
Adjustments to teacher's agenda	Move through a series of questions in accordance with planned agenda	Adjust questioning to accommodate students' contributions and respond to students' thinking
Nature of questions and responses	Recall, lower order, closed with predetermined short answer	Open, engage students in taking more responsibility for thinking (higher-order thinking); responses are longer, calling for one- or two-sentence answers
Teacher's response	Praise correct answers; correct wrong answers; treat students' challenges to her questions as threat	Delay judgment; accept and acknowledge student contributions in a neutral rather than evaluative manner
Authority for judging answers	Teacher is authority and asserts knowledge claims that she expects students to accept without debate	Shift authority for evaluating answers from teacher to all students

Source: Chin, C. (2007). Teacher questioning in science classrooms: Approaches that stimulate productive thinking. *Journal of Research in Science Teaching, 44*(6), 815-843.

The repetitive questions corresponded to 64% of total number of questions, and response rate were generally decreased after these questions. The researchers further observed that increase in the teacher use of wait time decreased the frequency of repetitions.

Stevick (1976) argued that individuals can keep a sentence in memory for 20 seconds before actually involving in understanding of its meaning and a few seconds of silence do no mean that students have not understood the question. Therefore, teachers should not need to repeat or rephrase a question. More than that, teacher permitting of wait time after any question is considered a very essential part of questioning. Teachers who use wait time at least 3-5 seconds results in less teacher-oriented classrooms (DeTure, 1979), and students have more opportunities to question, analyze, compare and interpret the ideas (Honea, 1982). Teacher's use of wait time after a question allows students some time to think over the question (Stahl, 1994). Unfortunately, the classroom studies of Rowe (1974) indicated that teachers generally do not permit wait time or give limited time after questions. One of the reasons for the limited amount of wait time can be explained with it is perceived as waste of class time (Dillon, 1988; Morgan & Saxton, 1991). This perception does not allow students time to focus on question, recognize it and mentally calculate what is being asked (Gall, 1984).

Although studies on teacher questioning patterns mostly focus on IRE or IRFRF sequences, Gall (1970) cautioned that there is less attention on examining the sequence of question types to initiate higher level student responses. Sequencing is a strategy for effective questioning in which teacher uses the question types in a patterned order indicating a purposeful questioning technique. This sequence required to examine the order of questions types as suggested by Taba (1966). Although the need for examining the sequence of question types was emphasized by the research review of Gall (1970) a few decades ago, studies did not give attention to this issue. The researcher of this study could not access any study focusing on the sequence of teacher question types after 1970s. This is particularly supported with a research review in a recent time conducted by Cotton (2001) in a way that the researcher did not report any study concerning the question sequence in an attempt to analyze characteristics of research on classroom questioning.

2.3.4.1 Analysis of Discourse Patterns

Research examining teacher questioning and student responses suggests various techniques to analyze what occurs during classroom interactions (e.g., discourse analysis, domain analysis, and content analysis). The present study found discourse analysis as most appropriate to apply because of the reasons that will be discussed in the next chapter. Through the classification or coding of questions and responses, researchers can gain insight into the question and response levels applied into the classrooms as well as their bilateral relations. Dantonio and Beisenherz (2001) identified that "Coding the questions and responses in a lesson is a way to understand the patterns of teacher questions, learner responses, and the relationships that exist between teacher questions and learner responses" (p. 77). Coding conversations to analyze questioning and response patterns would provide not only understanding into the change over time (Bolen, 2009) but also assessing the effectiveness of teacher questions to promote student cognitive skills in practice.

Similar to question classification systems discussed in a previous section, classifying or coding of learner responses requires taxonomies involving various cognitive operations. The representative question classification systems (e.g., Bloom's, Schreiber's, Aschner's taxonomy) can also applied to code student responses in studies. However, as indicated previously, these taxonomies do not practical to use in classifying cognitive demands (Gall, 1970; Krietzer & Madaus, 1994; Sugrue, 2002). In a more recent time, Grimberg and Hand (2009) developed a classification system by examining laboratory reports of students in ABI classrooms. They revealed 11 cognitive operations, ranging from simple to more sophisticated one.

Although the most highly cited taxonomy is Bloom's in education literature (Morgan & Saxton, 1991), the classification system developed by Grimberg and Hand (2009) is more favorable to apply in the present study because of several considerations. First, it was currently developed in a standards-oriented classroom based on empirical data rather than theoretical assumptions. Secondly, it is practical to classify student response since it includes numerous categories (N=11). Bloom's taxonomy was criticized by Gall (1970) as having limited number categories to classify questions. The third and probably most advantageous aspect of the system lies under rationale behind the categorization of 11 operations into 3 complexity levels, which are perception, conception, and abstraction. Higher order cognitive skills require individuals to make connections between two or more elements in various domains (Amer, 2006; Furst, 1994). The cognitive processes should require mastery of complex categories, which covers "all less complex categories below it" (Anderson et al., p. 309). As suggested by the researchers, Grimberg and Hand constructed the classification system considering number of domains involved in each cognitive operation with an inclusionary aspect that complex operations require the practice of less complex ones. Low level operations were associated with student use of ‘perception’, the complexity increases with student use of ‘conception’. The highest level requires student practice of ‘abstraction’.

Perception includes o*bservation, measurement* and *comparison* which are noncomplex, one dimensional operations. The complexity increases with *analogy* since it requires relation of two elements in two different domains: the source and the target. Similarly, c*larification, claim* and cause/effect operations require students to relate two conceptual domains. Thus, they were classified together in the same category. The highest level requires student practice of ‘abstraction’, such as induction, deduction, investigation design, and argumentation. *Induction* requires relating more than two domains as individuals are extracting few instances (pre-inductive domains) to general premises (inductive domain). Similarly, *deduction* establishes relationship between more than two domains as individuals draw particular instances from general principles. *Investigation design* is a complex operation since it provides individuals integrate questions, claims, and inferences. Lastly, *argumentation* involves more than two domains as integrating the operations mentioned above, such as questions, claims, clarifications, inductions.

2.3.5 Why Aren't Teachers Asking The Effective Questions?

Questions are so important in the nature of classrooms (Wilen & Clegg, 1986) that teachers need to be professional questioners (Gall, 1984). Although effective question type is determined as to be open-ended or high-level questions in education literature; it is mostly found that teachers pose predominantly cognitive-memory or factual-recall questions (Crawford, King, Brophy, & Everston, 1975; Cunningham, 1977; Gall, 1970; Gallagher, & Aschner, 1966; Greenough, 1976; Graesser & Person, 1994). In this manner, it is contradictory in education literature whether teachers need to ask more open ended-questions than close-ended type in effective questioning. Several researchers found that in high quality science classrooms, teachers asked more open-ended questions than close-ended type (e.g., Erdogan & Campbell, 2008; Martin & Hand, 2009), whereas several others claimed that it may not be necessarily required to use higher level questions more frequently than lower level ones to initiate higher-level thinking among students (e.g., Goodwin et al., 1983; Konya, 1972). This group of researchers support that it is important to use systematic and purposeful questioning techniques consisting of both higher and lower level questions together. As can be inferred, it is controversial what constitutes an effective teacher questioning. This brings the questions that in which proportions should teachers apply the question types in an effective questioning.

However, several researchers attempted to provide insight into the reason why teachers are not proficient to involve students in higher thinking skills. Storey (2004) listed some reasons that "teachers are commonly a) unfamiliar with the many classifications of questions, (b) unaware of the concept of cognitive correspondence, (c) constrained by standardized test, (d) inattentive to student schema, and (e) unskilled in effective questioning techniques" (p. 44). The researcher defined ineffective questioning as teacher's frequent use of lower-level questions relying on factual information.

Higher level questions will not always result in higher level thinking (Dillon, 1982; Sanders, 1966); however, teachers must ensure the cognitive correspondence that the level of student answer is on the same level of teacher question rather than requiring responses, which are not cognitively respondent (Bradtmeuler & Eagan, 1983; Morgan & Saxon, 1991; Sanders, 1966; Shore, 1992). In order to achieve this, teachers primarily required to be aware of question classification systems (Storey, 2004).

Savage (1998) argued the reason why teacher questions dominantly rely on close-ended nature in a way that the classroom interaction is controlled by the standardized tests since they require teacher dependence to textbook questions. However, textbook questions are generally lower-level that involve students in memorization of facts (Savage, 1998). This result in dominant questioning of lower-level type and classrooms correspondingly become more teacher-centered.

While above discussed reasons handled ineffective questions as teacher frequently use of lower-level questions, several researchers argued for even if teacher asks higher level questions, students may not involve in higher thinking skills. Gall (1970) argued this issue relying on ineffectiveness of commonly used classification taxonomies to observe real high-level questions or thinking skills. Question classification systems "were designed primarily to investigate the types of questions which teachers actually use in the classroom, not the types of questions which teachers should use" (p. 7). Although Gall claimed it in 1970, the issue is still important to take into account since most of the dominantly used classification systems were developed before that time. Considering Gall's point, it can be referred that what is labeled as high-level question might not be actually categorized in this level. The researcher further suggests developing question classification systems in specific curriculum. That means, if the focus of research is on question types in art lesson, the representative examples of the types must be observed in this curriculum.

Additionally, teacher unawareness of student experiences of schema that they bring to classrooms (Piaget & Inhelder, 1969) affects student responses (Bean, 1997); thus may result in ineffective questioning. An expectation of higher level thinking without considering student schema (Piaget & Inhelder, 1969) is an ineffective effort (Moll & Greenberg, 1990). In this regard, several researchers (DepHt, 1988; Heath, 1983; Moll & Greenberg, 1990; Valedes, 1996) examined impacts of culture on student responses in order to determine whether effective teacher question show variety across different cultures. Valedes (1996), for instance, observed that students of Mexican descent may be uncomfortable in answering questions orally. The researcher claimed that Mexican American children do not want to be disrupted in their utterances thus, it may be better to involve them questioning in one-on-one manner. Furthermore, lack of response in this culture does not provide signs that children do not know the answer instead they generally feel uncomfortable in answering questions. Culture was used as an example in order to provide insight into how student prior experiences may impact their responses and teacher questioning behavior. It may be impractical to delineate the characteristics of culture of students in a classroom, but Hyun (1998) suggested that teachers should be aware of the student valuable knowledge and experiences that they bring to classrooms. Additionally, in this sense, it may be important to adopt a research methodology of case study design in questioning studies, since Merriam (1998) asserted that it allows researchers to provide an 'intensive, holistic description' regarding the participants. A description regarding participants' demographic or cultural backgrounds in a case study may provide readers to gain insight into the characteristics of background differences.

The last consideration of Storey (2004) in teachers' ineffectiveness of questioning strategies underlies the need for professional development in questioning skills. Teacher's lack of training in questioning prevents quality questioning in classrooms (Otto & Schuck, 1983). Teachers need to be trained to improve their art of questioning (Dantonio, 1990; Fairbairn, 1987; Joyce & Showers, 1980; Joyce & Showers, 1983; Otto & Schuck, 1983; Ryan, 1973; Savage, 1998; Sitko & Slemon, 1982). Bolen (2009) asserted that researchers have emphasized the need for professional development over a century in an attempt to increase the amount of higher level questions and effective questioning. However, there are limited studies on examining teacher questioning along with professional development programs (Bolen, 2009).

2.3.6 Improving Teacher Questioning

Fairbairn (1987) asserted that questioning is a scientific process and teachers need to be trained in the art of questioning. There are different ways to train teachers as effective questioners (Otto & Schuck, 1983; Ryan, 1973; Savage, 1998; Sitko & Slemon, 1982). Houston (1938) developed in-service training program in order to improve teacher questioning practices. The program included group conferences, self-analysis and supervisory evaluation. Data gathered from eleven teachers indicated that majority of teachers improved their particular aspects of questioning behavior. These aspects included percentage of teacher questions in the classrooms, student participation and percentage of questions requiring manipulation of facts. Furthermore, several negative teaching behaviors such as repetition of questions, answering own questions and interrupting student answers were reduced.

Several research has been conducted to compare the efficiency of various programs in developing teacher questioning techniques. For instance, Allen, Berliner, McDonald, and Sobol (1967) applied to a videotape of a model teacher, who uses a large number of high-level questions, and tested the degree of efficiency of both visual instruction (videotape of an instruction of model teacher) and written instruction (transcript of the video). The researchers concluded that both techniques are equally efficient to improve student teachers' higher cognitive questioning. Similarly, Koran (1969) tested the relative effectiveness of videotapes of model teachers by observing preservice teachers in science classes. The researcher revealed that videotape of a model teacher was more effective than other several techniques such as traditional college instruction involving lecture and demonstration of effective questioning behaviors.

Sitko and Slemon (1982) reported that a coaching technique is efficient to improve questioning skills. In their study, the researchers required teachers to read a module in order to learn a system for categorizing questions. Classroom question sequences were observed by coders after the treatment and changes in the types and distribution of questions were observed. Teacher applied a variety of question types rather relying solely on cognitive-memory or factual-recall questions after the treatment. Similarly, Savage (1998) found that teachers can be trained in workshops to become effective questioners. The researcher implemented a total of eight workshops in which teachers were required to review types and purposes of questions. They were provided a guided practice to increase the practice of asking higher level questions.

The researcher concluded that workshops provided teachers to ask more high-level questions.

Since workshops usually provide a way to train large group of individuals in a short time period (Sork, 1984), it is a commonly applied practice in teacher trainings. Most of the training programs were conducted in short sessions; it is not common to examine teacher pedagogic practices in sustained, long-term programs (Benus, Yarker, Hand, & Norton-Meier, 2013). One session training programs, which are called by Budde (2011) as "one-shot session, sit-and-get and one size fits all approaches" (p. 21) are very common types of the teacher professional development (Darling-Hammond, 2005; Darling-Hammond & McLaughlin, 1995; Lieberman, 1995; Shibley, 2001; Xu, 2002).

Examining the characteristics of questioning studies, in this sense, two types of research has emerged. One type is those training teachers with an individual focus on questioning skills and the other type aims improvement in questioning with a holistic focus on pedagogic practices concerning teacher belief. As discussed above, several researchers favor the need for focusing on teacher belief in order to attain a development in any specific strategy. More evidence regarding this issue was provided by Omar (2004). As discussing the changing indicators of science toward implementing inquiry-based or constructivist approaches, the researcher indicated that teacher shifting practice in dialogical interaction can be achieved by teacher understanding of the foundations underlying why students should be at the center of classroom interaction. This can be achieved by teacher understanding of the fundamental theories and practices regarding inquiry-based approaches. Furthermore, possessing a deeper understanding is not enough; teachers need to transform their understanding into practice (Omar, 2004). In this sense, questioning skills should be addressed by considering teacher pedagogic beliefs and practices regarding reform-based science education instead of a narrow focus on questioning skills.

2.3.6.1 Milestones of Professional Development Programs

Professional Development (PD) programs have been conducted mostly in traditional forms such as workshops, conferences, seminars and presentations (Garet, Porter, Desimone, Birman, & Yoon, 2001; Porter, Garet, Desimone, & Birman, 2003). These forms have been frequently criticized in education literature that they are inefficient to promote meaningful changes in teaching practices since teachers are not provided with sufficient time and content (Loucks-Horsley, Hewson, Love, & Stiles, 1998). It is most likely in these forms to expose teachers to an expert's presentation of a set of skills instead of engaging them in real practice or experience of actions.

Investigations into the quality of PD programs revealed that teachers should experience the process as learners (Radford, 1998). Teacher learning occurs in a similar way that of students' (Fullan, 1996; Lieberman, 1995). The shift of science education from teaching-centered to learning-centered view is also evident in teacher training initiatives. In this sense, Lieberman (1995) cautioned that "… what everyone appears to want for students-a wide range of learning opportunities that engage students in experiencing, creating, and solving real world problems, using their own experiences, and working with others- is for some reason denied to teachers when they are the learners" (p. 591). PD opportunities should provide teachers to experience science for themselves in a way "they will want their students do" (Loucks-Horsley et al., 1998, p. 13). Furthermore, the programs should comprise "follow-up experiences with multiple interactions" (Luft, 2001, p.552). Reform movements strongly suggest systematic follow-up and ongoing support in the structure of PD programs (Danielson, 2006; DuFour & Eaker, 1998; Feiman-Nemser, 2001; Gunel & Tanriverdi, 2014; Kent & Lingman, 2000; Killion, 2000; Lewis, 1997). Follow-up activities aims to provide teachers implement what is learnt in PDs focus in their own classrooms (Danielson, 2006; Darling-Hammond, 2000; DuFour, Eaker, & DuFour, 2005).

The importance of follow-up activities and ongoing support in PDs has brought along the need for longitudinal programs. The shifting in teacher pedagogic practices requires at least 18 months (Gunel & Tanriverdi, 2012; Martin & Hand, 2009). Effective PD programs should be long term and target many complex values: pedagogy, beliefs, and perceptions that affect teacher classroom practices (Yager, 2005).

Several researchers argued that even though the focus of the training program is a specific skill or practice; it should be conducted by targeting teacher existing beliefs, knowledge, and habits of practice. Teacher's belief must become an explicit target of change. “Without such change as a priority, efforts directed at teacher development become narrowly focused on changing the kinds of attributes and skills that may be added to, subtracted from, or modified" (Windschitl, 2002, p. 143). Similarly, Haney, Czerniak and Lumpe (1996) discussed the requirement of a special attention into teacher beliefs while improving teacher specific skills. If a teacher views teaching practice as a transmission of knowledge, any focus on a change of a particular strategy will be senseless (Omar, 2006). Thus, professional development programs should target teacher beliefs that interact with their practices (Richardson, 1990). These beliefs generally concern teacher own role in classrooms and how learning occurs (Cronin-Jones, 1991). Teacher understanding of how learning occurs help them to reconstruct beliefs about the role of teacher and students in the classrooms, which in turn affect the way they teach (Levitt, 2001; Luft, 2001; Richardson, 1996). Teacher belief is a very important component of teacher decisions on adopting and sustaining any reform based practice (Abell & Roth, 1992; Bybee, 1997; Cohen & Ball, 1990; Cooney & Shealy, 1997; Woodbury and Gess-Newsome, 2003).

Researchers and practitioners agree on the following characteristics in high quality professional development programs (Banilower, Heck, & Weiss, 2007; Bryant, 2008; Elmore, 2002; Kanaya, Light, & Culp, 2005; Loucks-Horsley, et al., 2003).

1. Ongoing process with an emphasis on continuous improvement (Danielson, 2006; Darling-Hammond, 2000; DuFour, Eaker, & DuFour, 2005; Killion, 2000; Lewis, 1997).
2. Constructed based on systems align with reform movements (Guskey, 2003; Kelleher, 2003; Sparks & Hirsh, 2000)
3. Data-driven programs in which teachers are provided evidence on student learning (Danielson, 2006; DuFour, Eaker, & DuFour, 2005; DuFour & Eaker, 1998; Guskey, 1995)
4. Collaborative and focusing on authentic problems (Jeanpierre, Oberhauser, & Freeman, 2005; Feiman-Nemser, 2001; Killion, 2000).
5. Inquiry-based and reflective on practice of teaching techniques (Darling-Hammond, 2000; 2005; Feiman-Nemser, 2001; Killion, 2000; Sparks & Hirsh, 2000).

In addition to above suggestions, in order to successfully develop teacher pedagogic practices, the participants should be willing to change their current practices. Researchers strongly agree that teachers need to feel dissatisfaction with their existing teaching methods since this will encourage them to use and sustain reform-based teaching in classrooms (Gess-Newsome, 2003; Feldman, 2000; Sarason, 1982; van Driel, Beijaard, & Verloop, 2005).

CHAPTER 3

METHOD

This chapter will address the methodology used to analyze pedagogical progression through teacher questioning in middle school science classrooms. First, the research design will be described with the rationale justifying the choice for the design. Then, research context, data collection, coding, and data analysis procedures will be explained. The chapter will be concluded with a discussion on the trustworthiness of the study.

3.1 Research Design

A case study research design was used to address each research question in this study. The case study research is an 'intensive, holistic description' of an individual unit (e.g., person, program, organization or community) (Merriam, 1991, p. xiii). It provides researchers opportunities with engagement in a deep holistic view of a phenomenon and may facilitate describing, understanding and interpreting of a research situation (Baxter & Jack, 2008; Tellis, 1997). The case study best fits to research strategy in this study since the study primarily focused on a description of the adjustments made by the teachers in their use of questions across different pedagogic implementation levels.

By examining the types of case study designs, Stake (1995) categorized the forms as intrinsic, instrumental, and multiple studies. The researcher further defined the intrinsic case study in a way that it is applied in understanding of a specific individual or situation. In an instrumental case study, on the other hand, the researchers engaged in understanding of something for a larger goal instead of describing a particular case. The third type, multiple- (or collective) case study, is the form of investigating multiple cases as part of an overall aim of the study. It is significant to note that although these three forms have distinct definitions, they can be used in combination in a study (Stake, 1995). Along the three forms of the case studies, the multiple-case study was the most appropriate design since the study examined two cases as a means of one overall aim. The study needed to first understand teacher questioning patterns in middle and high classroom implementations in each case, and then, collectively describe teacher questioning characteristics considering two cases. The research questions will be addressed for each case separately, and then cross-case comparisons will be applied to determine the convergence and divergence among the results of two cases.

The present study found case study as the most appropriate design because of the research indicating that teacher questioning behavior shows variety from teacher to teacher (Schreiber, 1967). Since the focus of the study was examining differences in teacher questioning occurred over a time period, the teachers were investigated individually and then cross-case comparison were conducted to show convergences and divergences between the findings emerged from two cases. The cross-case comparison provides data interpretation through analysis of the convergences and divergences in and between cases (Merriam, 1998). The cross-case analysis design aims to indicate similar and different characteristics of the results from multiple cases. While “the differences between the cases may lend interest to each individual case” the similarities may contribute to the focus of the study (Harootunian, 2007, p. 159). Furthermore, by allowing the researchers to compare the cases from one group to another, the cross-case analysis provides opportunities to learn from different cases and collect evidence to modify policy (Khan & VanWynsberghe, 2008).

As a whole, by applying a multiple-case study using cross-case analysis, while the researcher was interested in teacher questioning characteristics, the focus was not on the individual cases. Instead, the attention was on how the teachers used questions in their different classroom implementations. This allowed for the interest on describing the differences in teacher questioning patterns between medium and high classroom implementations rather than focusing on a specific case.

3.2 Research Context

In this section, the researcher will provide rich contextual information regarding the cases. Each case is a teacher, who implemented both medium and high-level of ABI teaching. The two teachers (two cases) as participants of the study were selected from a professional development (PD) program that was conducted in Turkey. First, the PD program will be described in detail, and then the descriptions will be provided regarding teacher's background, experience in the PD program, and classroom and school settings.

3.2.1 The Professional Development Program

The teachers were selected among participants enrolled in a 3-year (6-academic semester) professional development (PD) program that was carried out within the scope of a project funded by The Scientific and Technological Research Council of Turkey (TUBITAK). The aim of the project was to improve teacher understanding and implementation skills of ABI teaching in middle school science classrooms. The participant teachers were able to build pedagogical knowledge and skills so as to enable their students to experience excitement and challenges of experimental and investigative science as well as to develop skills suggested by the current science reforms In order to achieve this objective, the structure and content of the PD program were designed by considering data-driven evidence, practice-based understanding and national science reform expectations regarding the classroom practices. In this section, the structure and content of the PD program will be detailed.

The program was conducted with a total of 30 science teachers working at middle schools located in different geographical regions of Turkey. The structure of the PD program included three major parts, which were in-service trainings, on-site professional supports, and assessment and measurement activities. Teachers attended to 3-day in-service training activities at the beginning of each academic semester. A total of 6 in-service training sessions was conducted across 6 academic semesters of the PD program. After each in-service training session, teachers received on-site professional support for the monitoring incentives as well as to accommodate their instructional needs and to encourage pedagogical development in ABI teaching. The researchers provided on-site supports in teachers' school settings at least once in each semester. On-site supports are perceived as the milestones of teacher pedagogical development in international PD contexts (Gunel & Tanriverdi, 2014). By analyzing the PD programs from international and national perspectives in Turkey, Gunel and Tanriverdi (2014) discussed for a need for longitudinal PD program those cover on-site supports based on the idea that learning is an ongoing process not only for students but also for teachers.

Within this continuous learning process, teachers implemented ABI teachings in their own classrooms and the classroom implementations were recorded with videotapes for the assessment and evaluation of the teacher progress. The teachers' classroom implementations were recorded at least in a unit in each academic semester of the 3-year PD program. The classroom videos were analyzed using Reformed Teaching Observation Protocol (RTOP) in order to measure the degree to which science classrooms reflect key features of ABI teaching. By analyzing teacher implementation level of ABI teaching in each semester, teacher progress was determined and the researchers had opportunities to provide feedback to teachers on their pedagogical progress throughout the PD program. The detailed information about the analysis of the teacher implementation level will be described in the next section of this study.

The in-service training activities implemented in 3 consecutive days at the beginning of each academic semester. The structure of the 3-day activities included the followings: 1) pedagogical discussions about learning and teaching, 2) hands-on inquiry experience as a learner, and 3) curriculum preparations for teacher implementation of ABI teaching in own classrooms. The content of the in-service training activities targeted teacher understanding of ABI teaching as well as change in teacher beliefs and perceptions regarding learning and teaching. The research on teacher change pointed out the fact that teacher pedagogical shifts in their practices cannot be achieved without a change in their perceptions and beliefs toward learning and teaching (Gunel & Tanriverdi, 2014). Thus, the PD program aimed to develop teachers' pedagogical practices by continuously challenging and probing their epistemological beliefs and perceptions.

Within the scope of the hands-on inquiry experience as a learner, teachers were immersed in ABI implementations within the selected curriculum-based unit so that they experienced the school based science topic as learners. Such activities not only illuminated the value and joy of ABI learning but also provided internal reflection about their own learning dynamics. The reason behind the teacher experience of a process as a learner lied under the teacher change research. The national and international research analysis in in-service trainings drew the attention on the need for teacher practice of the training process as a learner in order to share of teacher own learning experiences and to draw own conclusions regarding how learning occurs (Gunel & Tanriverdi, 2014).

At the end of 3-day in-service training program, teachers redesigned a curriculum-based unit to implement ABI teaching in their own classrooms. Through close collaboration with researchers, teachers selected and redesigned a unit by generating series of ABI activities, discussing about evaluation tools and obstacles to be faced during the implementation. The above mentioned structure and content of the PD program was summarized in Table 3.1.

Table 3.1. The Content and Structure of the PD program

The Professional Development Program	Content Components		Description	Purpose
	In-service Training Activities	*Pedagogical Discussions*	Constructing an understanding of learning and teaching	Scaffolding teacher perceptions through learning and teaching of science to better inform and guide the development of the necessary pedagogical practices
		Hands-on Inquiry Experience	Immersing teachers in ABI activities within the selected units so that they can experience the process by themselves as learners	Development of familiarity with hands-on activities
		Curriculum Preparations	Development of unit plans and potential pathways activity	Successful implementation of ABI inquiry teaching in actual classrooms
	On-site Professional Support		On-going support in teachers' school settings by the school visit of researchers	Teacher engagement in ABI teaching; accommodation of their instructional needs; monitoring incentives
	Assessment and Measurement		Analysis of classroom videos recorded by teachers during ABI implementations in their own classroom environments	Providing feedback on teacher pedagogical development after each semester in the program

3.2.2 Participants

The participants in this study consisted of two science teachers. The teachers will be called as Teacher A and Teacher B, later in the study. In this section, first, sample selection procedure will be explained and then, the description of each teacher's background, experience in the PD program, implementation unit, and school and classroom settings will be addressed separately for two teachers.

In order to select participants of the study from those involved in PD program, the researcher applied purposive sampling to attain teachers in their various implementation levels of ABI teaching. Purposive sampling was suggested to be applied when researchers select a sample using their judgment by considering participant prior information (Fraenkel & Wallen, 2006). The criteria to select teachers were their implementation level of ABI teaching. Each teacher was selected by considering availability of their medium and high-level of classroom implementation of ABI videotapes. Since there is a limited availability of the taped data from low implementation level classroom videos of the teachers, only medium and high-level classroom implementations were investigated in the study. This will be reported in the limitations part of the study in detail.

The implementation level of ABI teaching of teachers (N=30), who participated in the PD program, was analyzed by using modified Reformed Teaching Observation Protocol (RTOP) (Martin & Hand, 2009) in each semester of the PD program. The detailed description of the instrument is provided in 'ranking mechanism for level of implementation' section of this chapter. The researcher of this study selected two teachers, each of that having both medium and high implementation classroom videos.

3.2.2.1 Teacher A

As a 30 year-old science teacher, Teacher A had 2 years teaching experience in a public school. She has taught the science subjects for $6^{th,}$ 7^{th}, and 8^{th} grade students. Her school is located in a small rural area in the central Anatolia region in Turkey. The students in the school were in a medium socio-economic statue considering the average class in Turkey. There were a total of 28 students in the classroom. The medium and high-level classroom implementation videos of the teacher corresponded to third and fourth implementation semester in the PD program. She conducted implementations with the same group of students studying in 6^{th} grade in both of the levels. The information regarding teacher classroom implementation is shown in Table 3.2.

3.2.2.2 Teacher B

Teacher B has been a science teacher for 17 years in public schools. He is 40 years old. He has taught the science subjects for 6th, 7th, and 8th grade students. His school is located in the southeastern Anatolia region in Turkey. The students in the school were in a low socio-economic statue considering the average class in Turkey. There were a total of 35 students in the classroom. The medium and high-level classroom implementation videos of the teacher corresponded to third and fourth implementation semester in the PD program. The teacher's medium and high-level implementations were recorded for the same group of students studying in 8th grade. The information regarding teacher classroom implementation is shown in Table 3.2.

As seen in Table 3.2, a total of four classroom videos in two teachers' classrooms included only whole-class discussion of the lesson. Since there is a limited availability of taped data from small-group discussions, the researcher decided to focus the analysis in whole-class discussions. This will be explained in the limitations part of the study. Moreover, the length of the each teacher videos was similar for the medium and high-level classroom practices.

The instrument was applied in the sample selection stage of the study. The scoring of all the classroom videos in the PD program's pool was published within the scope of the final report of the project. All of the coders of the RTOP were experienced researchers in the use of the instrument.

Table 3.2. Information regarding the Classroom Implementations

Teacher	Semester in PD program	Implementation Level	Grade Level	Topic of the Lesson	Duration of Whole-Class Discussion(min)	Number of Students
A	3	Medium	6th	Reproduction, Growth and Development	57	28
	4	High	6th	Electricity in Our Lives	61	28
B	3	Medium	8th	Force and Motion	58	35
	4	High	8th	Light and Sound	57	35

The RTOP is an instrument to measure the degree to which science classrooms reflect the key features of science standards (Piburn & Sawada, 2000). The original RTOP developed by Piburn and his colleagues (2000) was designed, piloted and validated by the Evaluation Facilitation Group from the Arizona and Iowa State Universities. The instrument was then modified by Martin and Hand (2009). The modified RTOP includes 13 items, which were categorized into four major components; 5 items for student voice, 2 items for teachers' role; 5 items for science argument and 1 item for questioning. The instrument has a scoring on a scale of zero to four points for each of 13 items. A zero point represents behaviors that did not occur while four-point represents behaviors that were very descriptive of the classroom. Higher modified RTOP scores were associated with teachers' high-level implementation of ABI teaching (Hand, & Norton-Meier, 2010; Martin & Hand, 2009). While the scoring range between 2 and 3 corresponds to medium-level classroom implementation, the range between 3 and 4 corresponds to high-level implementation of ABI teaching. The modified RTOP is provided in Appendix A.

Whereas RTOP was applied as a scoring rubric in order to determine the quality of ABI implementation at various levels, as its name implies, it also serves as a protocol. Observation protocol works as a guideline by providing detailed information on the observed behaviors. It serves as a guideline about the criteria to define teacher quality of ABI implementation.

3.2.3 Criteria for Levels of ABI Implementation

In an attempt to modify the observation protocol (RTOP), Martin and Hand (2009) constructed different criteria in order to define various implementation levels of ABI teaching. In this study, the medium and high level implementation of ABI teaching referred to degree to which the classroom implementation reflects the criteria that suggested by Martin and Hand (2009).

The primary criterion in determining the implementation level of teachers is their ability to promote dialogic interaction by increasing student voice in the classroom. A researcher can determine the degree of teacher implementation quality by observing teacher-student interaction as well as student-student interaction in classroom conversations. Students should be engaged in negotiation of meaning with their peers, and the teacher in small or large group discussions. Whereas this practice occurs in the form of a monologue in traditional classrooms in which teachers are the authority of the talk, the ABI learning environments require experiencing dialogue instead of monologue where individuals scaffold their own knowledge through talking and listening each other (Norton-Meier, Hand, Hockenberry, & Wise, 2008).

The second criterion to determine quality of teachers' ABI implementation is the teacher role as a 'resource' person instead of a controller of knowledge in the classroom. In case of teacher control of classroom conversations rather than adoption of the role as a 'resource', 'guide' or 'discussion mediator', the focus and direction of the classroom discourse are dominated by the teachers. Such a learning atmosphere threatens student participation in negotiation own ideas, which in turn limits their construction of knowledge. In an ABI learning environment, students should be free to decide investigative decisions and discuss about the process and products on the own investigations (Martin & Hand, 2009).

The third criterion to define teacher implementation levels is associated with teacher ability to promote science argument among students. Students must be encouraged to participate in though provoking activities. Teachers should actively engage students in constructive criticism and challenging of own ideas. The questions that the teacher asks in the classroom can initiate or limit science argument among students. The types of teacher questions, "the kinds of responses the teacher used to respond to student questions and/or responses to the teacher's questions" affect student discussion of their claims and evidence (Omar, 2004, p. 66). Teacher ability to use effective questioning has core importance to increase student voice and actively engage them in science investigations and science argument (Martin & Hand, 2009). Teacher questions must initiate divergent modes of thinking in students in ABI classrooms (Piburn & Sawada, 2000). Effective teacher questioning is a crucial factor effecting teacher quality of ABI implementation since it has potential to initiate dialogical interaction and to encourage students to analyze and criticize opinions and concepts, which in turn will help them construct meaningful science learning (Omar, 2004).

3.3 Data Collection

Data were collected from classroom videos of two teachers participated in longitudinal PD program. As a reminder, each teacher implemented ABI teaching across six consecutive academic semesters of the PD program. They attended to 3-day in-service training at the beginning of each semester and then, carried out ABI implementations in their own classrooms. The classroom videos of the study were taken from each teacher's third and fourth implementation semesters in the PD program. As described in the 'participants' part of the study, the reason behind the selection of these semesters lied under the teacher implementation quality of ABI teaching in these semesters. Each teacher experienced medium-level of argument-based inquiry practices (MLABIP) in the third implementation semester and high-level of argument-based inquiry practices (HLABIP) in the fourth implementation semester of the PD program.

As shown in Table 3.2, the duration of whole-class discussion was similar in MLABIP and HLABIP of each teacher. The medium and high implementations were conducted with the same group of students for each teacher. The classroom videos served as the major data source of the study. All of the videos were transcribed by the researcher and then, the data was collected through two instruments based on the transcribed classroom videos. The transcripts were coded by using the instruments that were detailed in the next section.

3.3.1 Instrumentation

As was mentioned before in the study, the modified Reformed Teaching Observation Protocol (RTOP) was applied for the sample selection. Two major instruments were used for the data collection of the study. These are taxonomy of questions types (Graesser & Person, 1994) and coding sheet of cognitive categories (Grimberg & Hand, 2009). The taxonomy of question types was used to code the teacher question types. The scheme of cognitive categories was applied to code student responses in order to determine the cognitive level of each. The transcripts of the classroom videos were examined in detail in order to identify all questions asked by the teachers and corresponding student answers. Teacher questions were coded based on four categories which are management questions, close-ended questions, open-ended questions and meta-cognitive questions. Corresponding student answers were coded to determine the cognitive level of each question, which includes three levels ranging from simple to more sophisticated ones. The detailed information regarding the instruments is provided below.

3.3.1.1 The Taxonomy of Question Types

The taxonomy of question types (TQT) was developed by Graesser and Person (1994) in order to identify the types of questions. It was constructed considering theoretical and empirical research. The categories were developed based on the information that question asks instead of considering kind of question stem (e.g., why, how, where, when, etc.). The classification did not rely on the initial word of the question. Moreover, all of categories are assumed to be independent from the subject and context of the lesson (Yang, 2006). By examining the theoretical foundations of the classifications, it was recorded by the researchers that the classifications were influenced by four theories; question answering theory, speech-act theory, communication based theory, and plan-based theory.

The researchers examined one thousands of questions considering their frequency and qualitative characteristics to develop TQT. The questions were categorized by degree of specification, content and question-generation mechanism to analyze their quality. The taxonomy finally included 16 items in four major categories. The four major categories are 1) close-ended questions, which require short answers and place few demands on the answerer, 2) open-ended questions, which expect long answers, 3) assertion, which needs extra explanation from the answerer, and 4) request/directive that requires action related to task in focus. The Cohen’s Kappa reliability coefficients were recorded as to be 0.96 or more. The taxonomy was considered to have potential in meeting all inquiries adequately by the researchers.

Lately, Hmelo-Silver (2003) revised the taxonomy of question types by observing additional question types which are monitoring, need clarification and group dynamics questions. Hmelo-Silver added three new categories and modified the taxonomy under three major categories which are 1) close-ended questions, 2) open-ended questions, and 3) meta-management questions. The researcher did not make any change in close-ended and open-ended question types but combined assertion and request/directive question categories in the original version by adding three minor categories (monitoring, need clarification, and group dynamics) under the meta-management question category. Close-ended questions invite specific knowledge and brief answers, which are usually a word or phrase response, and place few demands on students. Open-ended questions require students to involve in extended answers as the answer usually requires interpretation, organizing and comparison of information (Graesser & Person, 1994). Meta-management category requires students to build on the new ideas offered by others with the engagement in agreement, disagreement, or modifying the ideas in the focus of discussion (Hmelo-Silver, 2003).

Although Hmelo-Silver (2003) addressed management and meta-cognitive questions into one major category (meta-management type); the researcher of the present study separated the categories as management type and meta-cognitive type. This separation was made by considering theoretical research and findings of this study. There was not any change in close-ended and open-ended question categories; however, meta-management category was modified by separating them into two distinct categories, which are meta-cognitive questions and management questions. Finally, the latest version of the taxonomy included 19 items as recommended by Hmelo-Silver (2003). Whereas Hmelo-Silver suggested categorizing these 19 items into three main categories; the researcher of the present study classified them under four major categories, which are 1) close-ended questions, 2) open-ended questions, 3) management questions, and 4) meta-cognitive questions (See Table 3.3.). The examples given to each question type was driven from the present study.

Management questions in the present study referred to monitoring and request for physical action, while meta-cognitive category referred to group dynamics, self-directed learning and clarification-seeking questions. Management questions are those applied to maintain a discipline in the classroom, while meta-cognitive questions in this study were assumed to involve students in higher order cognitive skills. This assumption depended on theoretical research as well as findings of this study by examining a total of 587 questions.

Higher order cognitive skills adopted in this study are induction, deduction, investigation design, and argumentation as recommended by Grimberg and Hand (2009) since these skills are more congruent with what science standards suggest. Within the scope of this study, the group dynamics, self-directed learning and need clarification questions under meta-cognitive category were found to invite answers from higher-order cognitive skills most likely than all other categories. The findings of this study revealed that meta-cognitive questions have the most potential among all to initiate student practice of high-level skills such as induction, deduction and argumentation. However, questions requiring monitoring and request for action had the least potential to invite practice of high-level skills among all other question types.

Since the questions under these two categories served to different purposes, this study separated meta-management question type into distinct groups. Although open-ended questions were claimed to be higher-order questions by Graesser and Person (1994), this study empirically revealed that it was meta-cognitive question type to involve student practice of high-level skills. Graesser and Person based their claim upon the taxonomy of educational objectives developed by Bloom and his colleagues (1956). In the Bloom's taxonomy, the high-level skills that students are required to practice are analysis, synthesis, and evaluation; and open-ended question type was argued to engage students in these practices.

Table 3.3. The Taxonomy of Question Types

Question Type	**Description**	**Example**
Management Questions		
1. Request/Directive	Request for action	Can you please look at the size of the egg and sperm? Can everyone sit please? Ahmet, do you listen to me?
2. Monitoring	Help check on progress, request for Planning	Is there anyone who can't read my writing? Can you hear your friend saying?
Close-ended Questions		
3. Verification	For yes/no response to factual Questions	Does the egg have a tail? Does the weight have a specific direction?
4. Disjunctive	Questions that require a simple decision between two alternatives	Which one can be easily immersed in a cup of water? Small ball or big ball? Which one is bigger? Egg or sperm?
5. Concept Completion	Filling in the blank or the details of the definition	When the density of it is smaller than water, it floats; but if the density is larger, it ……
6. Feature Specification	Determines qualitative attributes of an object or situation	Where does the reproduction occur? Which part of the wire does not transmit the electricity?
7. Quantification	Determines quantitative attributes of object or situation	How many legs do you think it has?
Open-ended Questions		
8. Definition	Determining meaning of a concept	What does zygote mean? What is the definition of insulator?
9. Example	Request for instance of a particular concept or event type	Can you exemplify this situation?
10. Comparison	Identify similarities and differences between two or more objects	What is the difference between copper wire and nickel-chrome wire that they gave a different luminosity to the bulb?

Table 3.3 (Continued)		
Question Type	**Description**	**Example**
11. Interpretational	A description of what can be inferred from a pattern of data	So, how do humans create a voice to be able to communicate each other? What can you conclude from this situation?
12. Causal Antecedent	Asks for an explanation of what state or event causally led to the current state and why	Why the vocal cords vibrate while talking? Why do we need to cover the wires with plastics?
13. Causal Consequence	Asks for an explanation of the consequences for an event of state	Why did you have difficulty when sinking the ball into water? Why did the density of lemon increase when you peeled it?
14. Enablement	Asks for an explanation of the object, agent, or processes allow some action to be performed	What would you observe when you put this object into the water? If When you throw this ball from a higher altitude, what would you observe?
15. Expectational	Asks about expectations or predictions (including violation of expectation)	What would happen if water or liquids do not have lifting force?
16. Judgmental	Asks about value placed on an idea, advice, or plan	What do we need to consider when generating a question?
Meta-Cognitive Questions		
17. Group Dynamics	Leads to discussions of consensus or negotiation of how group should proceed	What do you say about your friends' assertion? Umit, what do you think on this? Do you agree with your friend?
18. Self-directed learning	Relate to defining learning issues, who found what information;	Can you ask a testable question on this issue? Can you write a question about sound that you are curious about?

Table 3.3 (Continued)		
Question Type	**Description**	**Example**
19. Need Clarification	The speaker does not understand something and needs further explanation or confirmation of previous statement	Vocal cords is getting thinner. Did you mean that? What do you exactly mean by amplitude?

Sources: Graesser, A. C., & Person, N. (1994). Question asking during tutoring. *American Educational Research Journal, 31,* 104-107.
Hmelo-Silver C. E. (2003, April). The constructivist teacher: Facilitating problem-based learning. Paper presented at American Educational Research Association Annual Meeting. Chicago, IL.

However, high-level skills determined by Bloom and his colleagues were criticized in several aspects. Analysis, synthesis, and evaluation operations as high-level skills have not been empirically tested to be the highest skills as claimed by Bloom's and his colleagues (Sugrue, 2002).

Additionally, it passed nearly 60 years from the development of this taxonomy, and changes in reform movements have emphasized more complex skills than what is emphasized in Bloom's taxonomy. The current standards highlighted the requirement of student practicing negotiation of meaning individually and with others through involving students in argumentation (Norton-Meier, Hand, & Ardasheva, 2013). However, high thinking skills determined as analysis, synthesis, and evaluation do not explicitly require these complex skills.

Amer (2006) indicated that Bloom's educational objectives do not involve learner-centered paradigms into its structure. For instance, constructivism assumes that students must discover, construct and negotiate knowledge on their own. This requires individuals to make connections between two or more elements in various domains (Amer, 2006). Furst (1994) provided several reflections on Bloom's taxonomy and reported that the cognitive processes are constructed on a single dimension, from basic to complex skills. This one dimension aspect does not require individual's to make relations in various domains. As Anderson and his colleagues (2001) reported that the taxonomy requires a "mastery of a more complex category required prior mastery of all less complex categories below it" (p. 309).

To sum up, the Bloom's taxonomy underlying the theoretical foundations of TQT was criticized not to include complex operations such as induction, deduction and argumentation. Thus, it is not surprising to find in this study that open-ended question type failed to involve students in these complex skills. This study revealed that it was meta-cognitive question category requiring student experience of higher-order cognitive skills.

3.3.1.2 The Coding Sheet of Cognitive Categories

The coding pathway was developed by Grimberg and Hand (2009) in order to categorize cognitive operations with the text analysis. The researchers revealed 11 cognitive operations by examining documents of students those performing laboratory activities by using the Science Writing Heuristic approach. These operations are "observations, measurements, comparisons, analogies, clarifications using questions or statements, claims, cause/effect relations, inductions, deductions, experimental designs, and argumentations" (Grimberg & Hand, 2009, p. 509). The researchers categorized these 11 operations into three major cognitive levels, ranging from simple to more sophisticated ones, by considering the complexity level of the operations (See Table 3.4). Examples given in Table 3.4 were driven from the data of the present study.

Grimberg and Hand (2009) explained the rationale behind the categorization of 11 operations into 3 complexity levels as the followings. *Observation, measurement and comparison* are noncomplex, one dimensional operations. The complexity increases with *analogy* since it requires relation of two elements in two different domains: the source and the target. Similarly, c*larification, claim* and cause/effect operations require students to relate two conceptual domains.

Table 3.4. Cognitive Categories and Definitions of Each

	Cognitive categories	Definition	Example
Level I (Perception)	1. Observation	Data that result from students' observations	The bulb was not burned in the insulator wire. They made an experiment with an aluminum folio.
	2. Measurement	Reference to any quantitative aspect of the data	The volume of the object was 1.25 liters; the volume of overflowing liquid was 0.35 liters.
	3. Compare	Reference to common/different characteristics of two or more pieces of data or objects	The volume of unpeeled lemon is greater than that of peeled lemon. When we put the egg in tap water, it sank; but when the egg was thrown into saline water, it floated.
Level II (Conceptions)	4. Analogy	Mapping elements from a source domain (well-understood situation) into a target domain (non-familiar situation)	While we are playing in the park, if I put some sand on the slides, it moves us faster. The material inside the wire causing a fast move can be something like this sand.
	5. Clarifications	Questions or knowledge that stimulate clarification supporting other operations	Then, how does the mouth of the shoes make this sound? The toys are not alive objects but they can produce sounds.
	6. Claim	Unproved inference or explanation	Electricity is a slippery substance itself. The magnitude of the resistor can't be same in every substance.
	7. Cause / Effect	Identification of a cause and its effect	The clay must include very few electrons because it did not transmit the electricity well. Since the density of water is greater than that of air, the gravity will be less in water.

Table 3.4 (Continued)			
	Cognitive categories	**Definition**	**Example**
Level III (Abstractions)	8.Induction / Generalization	Reasoning that links few examples to general premises	If a man, who cannot swim, goes into the water, he dies. When he dies, he comes up to the surface of the water; and it floats. Then, we can say that inanimate objects can float on the water, but living beings sank in case they cannot swim.
	9. Deduction / Logic	Reasoning that links general premises to a specific	The sound propagates in the form of waves. For instance, wherever we are, we can hear the sound of a horn.
	10. Investigation design	Planning new experiments	I can combine all of these woods together, and then put a piece of iron on it. What happens? The wood floats or sinks?
	11. Argumentation	Negotiation of meaning with others.	Hakan said that the baby cannot grow inside a cell. But the egg of ostrich is a cell and baby ostriches are grown inside this egg cell. Then, how could this happen? You said that air particles.. How did you know that the reason of floating of the lemon is air particles? Can you prove it to us?

Source: Grimberg, B. I., & Hand, B. (2009). Cognitive Pathways: Analysis of students' written texts for science understanding. *International Journal of Science Education*, *31*(4), 503-521.

Induction requires relating more than two domains as individuals are extracting few instances (pre-inductive domains) to general premises (inductive domain). Similarly, *deduction* establishes relationship between more than two domains as individuals draw particular instances from general principles. *Investigation design* is a complex operation since it provides individuals integrate questions, claims, and inferences.

Lastly, *argumentation* involves more than two domains as integrating the operations mentioned above, such as questions, claims, clarifications, inductions.

The number of domains in the operations or complexity of each allowed clustering them into three levels: Level I (low level) or one-domain operations, Level II (medium-level) or two-domain operations, and Level III (high-level) or multi-domain operations. Low level operations are based on perceptions, while medium and high-level operations are based on conceptions and abstractions, respectively.

3.4 Data Coding and Analysis

The transcripts of the four classroom videos were examined to identify each teacher question and corresponding student response. The teacher questions were coded using modified version of Graesser and Person's (1994) taxonomy of question types. Four major categories were coded. These are management questions, close-ended questions, open-ended questions and meta-cognitive questions. As in the study of Hmelo-Silver (2003), any question that did not fit in these categories was labelled as none. Most of the teacher questions coded as none included questions such as "All right? Okay?" Student responses were coded so as to determine whether they corresponded to low, medium or high cognitive level operations.

Once all the coding was finalized by the researcher of this study, they were revised by a second coder. The codes in the transcripts of each classroom video were checked by one external researcher, with a total of four researchers for four classroom videos. Then, the researchers came together to solve the emerging disagreements.

The study used discourse analysis method in order to answer each research question. Onwuegbuzie, Dickinson, Leech and Zoran (1993) defined discourse analysis as the act of investigating individuals' words or phrases in order to critically define the processes that occur in social interactions. The research questions were analyzed within each individual case. Then, cross-case comparison was applied to analyze similarities as well as differences among the cases regarding teacher use of questioning. The section will detail the analysis procedures for individual case study and cross-case study, respectively.

3.4.1 Individual Case Study Analysis

The data analysis for each teacher case is provided in order of research questions of the study, which are:

1. What are the differences in teacher question types occurred in medium and high-level ABI teaching practices?
2. What are the main characteristics of teacher questioning patterns in medium and high-level ABI teaching practices?

3.4.1.1 Research Question 1

The first research question was answered by using qualitative and quantitative approaches together. First, categorization was applied to code and analyze data. The researcher determined the categories before the analysis began and counted the frequency of each incidence in the category. Since the end product was the numbers (e.g. frequency of certain words, symbols, pictures, etc.), it provided to interpret the data through the use of frequencies and percentages and/or proportions of particular incidences to total incidences.

Once all the coding was finalized, the frequency of questions for each question type was tallied. Then, cumulative frequency scores were determined for each question type in MLABIP and HLABIP. Although not part of the research question, a tally was also made for the total frequency of questions asked in the medium and high-level practices. The categorical data was presented in the form of a frequency table, which showed the frequency of question type in each implementation level. The relationship between two categorical variables, which are teacher question type and implementation level of ABI, was tested by using a Chi-square test for two independent samples. In case of a relationship, a Chi-square test for two independent samples was applied to describe the differences in teacher use of questions in MLABIP and HLABIP.

Besides asking individual questions, since the teacher asked a series of questions, which were not interrupted by student responses, the total number of questions included in multiple question strings was also tallied. The discourse analysis was applied to compare the frequencies and patterns of multiple string questions in MLABIP and HLABIP.

The Chi-square as a nonparametric test does not concern normal distribution of data or equality of variances. The assumptions of the test are the followings: 1) random samples 2) independent observations 3) the frequency of the observed variables ($N \geq 5$) (Pallant, 2005).

All these measures were taken in this study except for the random sampling method. McHugh (2013) argued that if the random sampling assumption is violated in non-parametric tests, researchers should apply several replication studies with essentially the same results obtained. As highlighted by the researcher, this study investigated two cases in order to verify the results of the research questions. Moreover, the aim of this qualitative study was not to generalize findings to all settings. Instead, the results can be considered within each individual case setting. The random sampling has significance for the generalizability of the results as required in all quantitative studies; however, this study did not much concern to generalize the findings. Instead, transferability is the main concern through the detailed information on data selection, collection and analysis procedures.

3.4.1.2 Research Question 2

With the aim of characterizing teacher questions upon student responses, the second research question was answered by using discourse analysis. In this question, the analysis results interpreted through the use of frequencies without conducting a Chi-square analysis. The obtained frequency scores did not ensure the assumption of Chi-square analysis which states that lowest frequency in any cell should be 5 or more (Pallant, 2005).

After student responses were coded to determine the cognitive level of each, the tally was made to identify the relationship between teacher use of question types and student use of cognitive operations. For instance, it was determined that how many high-level student responses were initiated by teacher close-ended questions. As mentioned above, since the frequency score in each cell did not ensure the Chi-square test assumption, the relationship was interpreted only by the comparison of the frequency scores.

Within the scope of this question, teacher questioning was handled by examining both teacher question types and patterns. The questioning pattern referred to sequence of teacher question types. The differences in the teacher use of questioning patterns between MLABIP and HLABIP were also interpreted through the discourse analysis. At the end, the characteristics of questioning patterns initiating student higher cognitive operations was determined and described considering the relationship between questioning pattern and the frequency of student higher cognitive responses.

3.4.2 Cross-Case Comparison

Cross-case comparison was conducted as the final form of the analysis in order to interpret the convergences and divergences of the results obtained from two cases. As suggested by Baskarada (2013), the analysis was conducted by *pattern matching* through identification of any similarities and differences between the cases.

Miles and Huberman (1994) claimed that cross-case analysis may increase the generalizability of the outcomes of the study, while it places less emphasis on the idiosyncratic elements of each case. Observing the same case with an increased number of individuals may decrease the characteristic peculiar of an individual. Through the use of cross-case analysis, teacher questioning characteristics in MLABIP and HLABIP became more evident. Moreover, since the characteristics do not peculiar to individual case, the replicated testing of these patterns supported the validity of the results (Yin, 2003).

3.5 Trustworthiness of the Study

In a qualitative study, credibility, transferability and dependability are the key issues to determine the trustworthiness of it (Marshall & Rossman, 2011). In order to ensure the trustworthiness of a study, "careful checking of data codes, continuous scrutiny of data for internal and external consistency, triangulation, and continuous assessment of respondent credibility, are important steps to take as counter measures" (Lincoln & Guba, 1985, p. 282). Triangulation through multiple data source was applied in this study by the comparison of the results from two cases. The use of multiple data source by cross-case comparisons leads to increase internal validity of a study (Government Accountability Office, 1990). Similarly, Richardson (2000) recommended considering "multiple views and overlaps of interpretations" at the same time in the data analysis of a study (p.14). Multiple interpretations were considered thorough analyzing two cases by cross comparisons.

The credibility of the study was aimed by regular discussions on the data analysis with peer-researchers in the field of science education as suggested by Lincoln and Guba (1985). The regular discussions were also conducted with the advisors of this study in order to reach an agreement on the interpretations and explanations to answer the research questions.

In terms of transferability, Merriam (1998) stated that the findings of a qualitative study should be applied to other or broader areas. In an effort to achieve this aim, as suggested by Lincoln and Guba (1985), the study provided rich contextual information regarding the PD program, participants and classroom settings. In this way, the readers were provided opportunities with determination of the conditions in which the study can be transferred to other areas.

In an effort to ensure the dependability of the study, the coding of the instruments made by the researcher of this study was also checked by external researchers who were experienced in using the instruments in their previous research. The disagreements on the scoring were solved through conversations on the transcripts. Additionally, the modified RTOP scoring was performed by three researchers independently with a 90% inter-rater agreement.

CHAPTER 4

RESULTS

This chapter will report the findings emerging from the analysis of two research questions of the study, which are:

1. What are the differences in teacher question types occurred in medium and high-level ABI teaching practices?
2. What are the main characteristics of teacher questioning patterns in medium and high-level ABI teaching practices?

The entire transcripts were coded to determine the teacher question types and cognitive level of student answers in medium and high-level of ABI classrooms. All the questions asked by teachers and corresponding student answers were identified. Four major categories of teacher questions were coded. These are management, close-ended, open-ended and meta-cognitive questions. Teacher questioning patterns emerged based on the sequence of teacher question types. Student answers were coded so as to detect the level of student cognitive operations, which include three levels ranging from simple to more sophisticated ones.

Within the scope of the first research question, teacher use of question types for medium-level of argument-based inquiry practices (MLABIP) and high-level of argument-based inquiry practices (HLABIP) will be presented. The differences of teacher question types between MLABIP and HLABIP will then be addressed in order detect the changes in teacher use of questions while teachers adopted high quality level of ABI practices. For the second research question, teacher questioning patterns will be characterized based on the sequence of question types for MLABIP and HLABIP, separately. Cognitive levels of student answers given to each teacher question will be presented. Finally, the characteristics of teacher questioning pattern to promote higher cognitive level student responses will be described for MLABIP and HLABIP.

The findings driven from MLABIP and HLABIP will be addressed within individual cases. A cross-case analysis will then be applied in order to interpret the similarities and differences of the results emerged from individual cases.

4.1 Case Study of Teacher A

4.1.1 Comparison of Question Types between Medium and High-level ABI Implementations

The frequency of questions for each question type was tallied. Then, cumulative frequency scores were determined for each question type in MLABIP and HLABIP. Although not part of the research question, a tally was also made for the total frequency of questions asked in the medium and high-level practices. A chi-square test was conducted throughout the analysis in order to examine whether the frequency scores of question types asked in MLABIP and HLABIP statistically significant from each other. The distribution of teacher question types by implementation level is provided in Figure 4.1.

As seen in Figure 4.1, while the teacher asked a total of 201 questions in MLABIP, she asked 183 questions in HLABIP. Although the total number of questions asked in the medium-level is more than those asked in high-level, a Chi-square test for one independent sample revealed that total frequency of questions does not significantly differ between each other, X^2 (1, n = 384) = .844, p = .358.

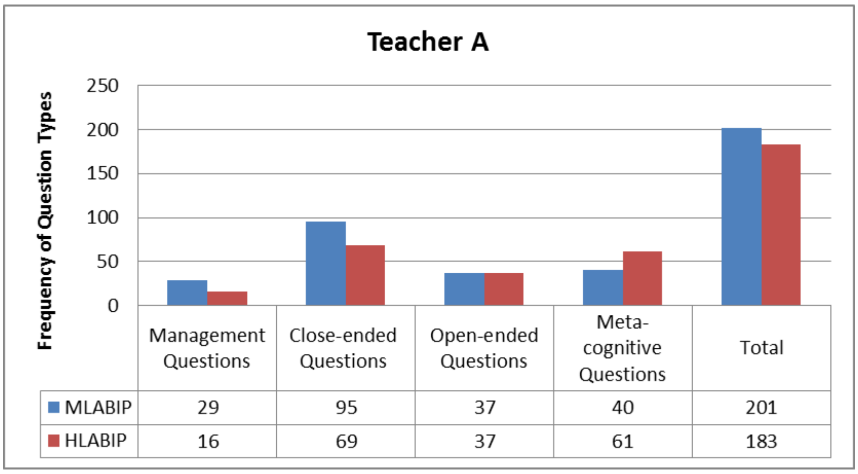

Figure 4.1 Distribution of Teacher Question Types by Implementation Level-Teacher A

In order to make comparison of the question types across medium and high-level implementations, it was determined that whether teacher use of question types significantly differ across MLABIP and HLABIP. The Chi-square analysis with three degrees of freedom revealed a significant relationship between teacher question types and the implementation levels, p = .013. Teacher question types significantly differed between medium and high implementation level of ABI teaching.

By examining the distribution of questions given in Figure 4.1, it is seen that while the most frequently used question type was close-ended questions in both levels, the least frequent one was the management questions. The frequency of meta-cognitive questions was larger than open-ended questions both in the MLABIP and HLABIP.

The detailed frequencies and percentages of questions from each question type for MLABIP and HLABIP are provided in Table 4.1. The results given in Table 4.1 are presented within the following categories: management question comparisons, close-ended question comparisons, open-ended question comparisons, and meta-cognitive question comparisons.

4.1.1.1 Management Question Comparisons

As seen in Figure 4.1, the teacher asked more management questions in MLABIP. However, a Chi-square value of 3.76 with one degree of freedom indicated non-significant difference in the frequencies of management questions those asked in MLABIP and HLABIP, X^2 (1, N = 45) = 3.76, *p* = .053.

When looking at the percentages of sub-management questions individually, ‘request/directive’ questions are the most preferred type by the teacher in both levels (See Table 4.1).

4.1.1.2 Close-ended Question Comparisons

The frequency of close-ended questions was greater in MLABIP. A Chi-square test for one independent sample analysis indicated that the teacher asked significantly higher number of close-ended questions in her medium-level practice, X^2 (1, N = 164) = 4.12, *p* = .042.

By examining the percentages of sub-types of the close-ended questions, it appears from the Table 4.1 that the teacher mostly applied ‘verification’ questions in both levels with 38% of the total questions asked in the medium-level and 28% of those asked in high-level. The decrease in the number of close-ended questions in the high-level implementation emerged from the significant decrease in the number of verification questions. While the teacher used just few disjunctive and concept completion questions, she did not apply any quantification questions in both implementation levels.

Table 4.1. Frequency and Percentage of Questions from Each Type for Each Implementation Level-Teacher A

Question Category	Teacher A			
	MLABIP		HLABIP	
	Frequency	Percentage	Frequency	Percentage
Management Questions	**29**	**15**	**16**	**9**
1. Request/Directive	19	10	14	8
2. Monitoring	10	5	2	1
Close-ended Questions	**95**	**47**	**69**	**38**
3. Verification	76	38	51	28
4. Disjunctive	5	3	3	2
5. Concept Completion	2	0	2	1
6. Feature Specification	12	6	13	7
7. Quantification	-	-	-	-
Open-ended Questions	**37**	**18**	**37**	**20**
8. Definition	2	1	3	2
9. Example	-	-	-	-
10. Comparison	4	2	3	2
11. Interpretational	14	7	15	8
12. Causal Antecedent	-	-	2	1
13. Causal Consequence	12	6	8	4
14. Enablement	-	-	-	-
15. Expectational	2	1	4	2
16. Judgmental	3	1	2	1
Meta-Cognitive	**40**	**20**	**61**	**33**
17. Group Dynamics	8	4	14	8
18. Self-directed learning	-	-	7	3
19. Need Clarification	32	16	40	22
TOTAL	**201**	**100**	**183**	**100**

4.1.1.3 Open-ended Question Comparisons

The frequency of open-ended questions did not differ between teacher medium and high implementation. However, open-ended questions accounted for 18% of questions asked in MLABIP and 20% of those in HLABIP. While examining the percentages of sub-types of open-ended questions, it is seen from the Table 4.1 that most of the questions were in interpretational and causal consequence types in both terms. The teacher did not apply other sub-categories in significant proportions. The percentage of other sub-categories of open-ended questions was equal or smaller than 2%.

4.1.1.4 Meta-Cognitive Question Comparisons

The teacher asked significantly more meta-cognitive questions in her high-level implementation, X^2 (1, N = 101) = 4.37, p = .037. While questions those required self-directed learning were not applied in the medium-level, the number was 7 in the high-level. It is significant to report that the largest difference in the sub-categories appears within the 'need clarification' questions with a 6% of increase in the HLABIP.

4.1.2 Comparison of Multiple Questions between Medium and High-level ABI Implementations

Besides asking individual questions, the teacher asked a series of questions, which were not interrupted by student responses, both in MLABIP and HLABIP. The total number of questions included in multiple question strings was tallied. Then, to give a more complete analysis, the multiple question strings were examined to determine the distribution of question types included in the strings.

The number of multiple string questions asked in MLABIP is very close to HLABIP. The teacher asked just one more multiple string questions in HLABIP (N=21). The number of individual questions was greater than multiple question strings in both MLABIP and HLABIP.

The length of the question strings was similar in both level implementations. The combinations of the question types in the strings were also similar. A more detailed analysis into the combinations of question types revealed that multiple string questions were usually asked with the aim of extending what the teacher meant in the first question or narrowing the range of student answers. The teacher asked a question, and she needed to ask another question in order to clarify the meaning in the focus of question or narrow the options in student answers. See the examples from actual conversation presented in Table 4.2.

Table 4.2. Example of the Teacher Use of Multiple Question Strings in HLABIP-Teacher A

Actual Conversation			
Speaker	**Utterance**	**Question Type**	**Comments**
Student	We need to cover the wires with plastics.		
Teacher	Why do we need to cover the wires with plastics? What happens if we do not cover it? What is the role of plastics on it?	OOO	Teacher asks an open-ended question and continues with further open-ended questions in order to extend what she meant.
Student	It prevents electric shock.	-	
Teacher	Then, how do plastics prevent electric shock? What is the distinctive feature of plastic in preventing electric shock compared to copper wire?	OO	Teacher asks a further open-ended question to narrow the range of student answer.
Student	It is insulator, not a conductor.	-	
Teacher	Which properties of materials result in better resistance? Think about a very long and very short wire; which one has the more resistance? What is the difference between their resistances?	OCO	Teacher asks a question then, specifies what she meant in order to narrow the range of student answers.

Table 4.2 (Continued)

Actual Conversation			
Speaker	**Utterance**	**Question Type**	**Comments**
Student	The flow of the electricity will be slow in the long wire.	-	
....			
Teacher	Okay then, why both of them is the same material? What would happen if we observe it separately in a copper and iron wires?	OO	Teacher extents what she meant with a second open-ended question.
Student	Copper is better conductor than iron. So, we could obtain misleading results.		
Teacher	What do we need to consider in the experimental process to achieve reliable results? If you repeat you experiment, would you make any changes in your design?	OC	Teacher asks a close-ended question in order to decrease the options in student answer.
Student	The wires must be identical in their length.	-	

*"C" refers to close-ended; "O" refers to open-ended question types.

4.1.3 Relationship between Teacher Questioning Patterns and Student Cognitive Operations in Medium and High-level ABI Implementations

This section will analyze teacher questioning patterns in MLABIP and HLABIP and then, examine the relationship between teacher questioning patterns and student cognitive operation levels. At the end, the characteristics of questioning patterns initiating student higher cognitive operations will be deeply examined.

Although not part of the research question, the distribution of cognitive level of student answers by teacher question type was tallied (See Table 4.3). The distribution scores indicated that teacher questions resulted in a few number of low level cognitive operations (Level I) in students both in MLABIP and HLABIP. Medium-level cognitive operations (Level II) were mostly initiated by close-ended questions. Additionally, high-level cognitive operations (Level III) emerged by meta-cognitive question type as the most in both implementation levels.

Table 4.3. The Distribution of the Cognitive Level of Student Answers for Each Question Type and Each Implementation Level-Teacher A

Teacher Question Type	MLABIP Cognitive level of the Student Answer			HLABIP Cognitive level of the Student Answer		
	Level I	Level II	Level III	Level I	Level II	Level III
Management	1	4	1	1	2	1
Close-Ended	3	37	5	6	14	7
Open-Ended	3	8	1	-	11	3
Meta-Cognitive	2	3	7	2	7	16

As mentioned previously, the present study revised the taxonomy of question types based on the analysis of the cognitive level of teacher question type and student response. In the taxonomy of question types, high-level questions are determined as to be open-ended type in which students are usually required to organize, compare and interpret information (Graesser & Person, 1994). Within the scope of this study, a total of 587 questions were examined in relation to student response levels and found that open-ended question type was failed to involve students in practicing complex skills such as induction, deduction, and argumentation (See Table 4.3). The present study empirically revealed that it was meta-cognitive question type to involve student practice of these complex skills. As seen in Table 4.3, while approximately 50% of high-level response was initiated by meta-cognitive questions in MLABIP, the percentage of high-level response that initiated by meta-cognitive question type is about 60 in HLABIP.

The categories under meta-cognitive questions, which are group dynamics, self-directed learning, and need clarification, were emerged in the study of Hmelo-Silver (2003). Hmelo-Silver revised the original taxonomy of question types that developed by Graesser and Person (1994) by frequently observing these additional question types. While Hmelo-Silver (2003) grouped these additional three categories under a meta-management question type, the researcher of the present study separated meta-management category into two as meta-cognitive questions and management questions, since the findings revealed that they served to different purposes in the classrooms. While meta-cognitive type including group dynamics, self-directed learning, and need clarification questions, had the most potential to initiate high-level response, management question type least frequently occurred in high-level response. Management questions served to manage or understand student directions while they are engaging in assignments or experiments in the classrooms but its frequency was too low in both medium and high-level classrooms. Below given Table 4.4 represents examples of the different roles that meta-cognitive and management questions served in student response.

Increasing the use of meta-cognitive questions in HLABIP involved in higher cognitive student answers; however, simply asking meta-cognitive questions did not direct students to practice higher cognitive operations. The teacher asked the questions in a patterned order indicating a specific questioning sequence. At the beginning of the whole-class discussion, she created a conceptual conflict with the frequent use of close-ended and open-ended questions and then, addressed this conflict with meta-cognitive questions to challenge student cognitive operations.

Table 4.4. Examples of the Different Roles that Meta-Cognitive and Management Questions Served in Student Response in HLABIP

	Actual Conversation			
Turn	**Speaker**	**Utterance**	**Question Type**	**Comments**
1	Teacher	Who will remind us the topic of the last lesson?	Request/Directi ve	
2	Student	How to we prevent electric shocks (The student is reading the sentence from her notebook)		Observation
….				
107	Teacher	Okay, can you write the definition of it on the board?	Request/Directi ve	
108	Student	There is something called ground line. Imagine that, they will supply electricity to this point. They need to cover it with a thicker wire and put the wire under the ground.		Clarification
….				
119	Teacher	Could your friends hear you? Could you hear what your friend said?	Monitoring	
120	Student	No.	-	None.
121	Teacher	Then, repeat it.	-	
….				
276	Teacher	If we want to observe it, how could you design your experiment?	Self-directed learning	
277	Student	I can use a short and long wire to observe it. The short wire will burn the bulb brighter.		Investigation design
….				
409	Teacher	Do the other group members have a question for this group?	Group Dynamics	
410	Student 1	They made an experiment with a copper and iron wire.. Turgut measured the copper wine but it didn't reach to…Then, can we say it couldn't reach. I couldn't explain it.		Argumentation
411	Teacher	What did you mean?	Need Clarification	

Table 4.4 (Continued)

	Actual Conversation			
Turn	**Speaker**	**Utterance**	**Question Type**	**Comments**
412	Student 1	I will explain it in another way. If they would combine the copper wire with nickel-chrome wire, and then make their observation. What happens to the brightness of the bulb? It increases or decreases?		Argumentation

*'None' category refers to utterances that did not fit into any cognitive categories.
*Turn indicates the line order of the utterance in the transcript.

The students both in medium and high-level implementations practiced high-level cognitive operation for the first time around the seventh minute of the whole-class discussion. Up to this moment, while teacher asked mostly open-ended and close-ended questions, she rarely applied to meta-cognitive type. When she asked meta-cognitive questions at the beginning of the whole-class discussion, students were not involved in higher cognitive operations. In this case, the teacher continued to challenge student conceptual knowledge by asking more open-ended and close-ended questions in multiple sequences. See the below examples of teacher-student interaction occurred at the beginning of the whole-class discussion in Table 4.5.

Majority of the questions asked in MLABIP consisted of close-ended and open-ended type. Teacher applied these types when the aim of her was to challenge student conceptual knowledge rather than higher cognitive operations. First, she constructed student conceptual knowledge then, addressed higher cognitive operations. Meta-cognitive questions were categorically better than other types to initiate student higher order cognitive operations; however, it did not necessarily mean that teacher needs to ask more meta-cognitive questions than the other types. Simply increasing the frequency of meta-cognitive questions did not lead students to produce higher order cognitive responses. The teacher should effectively combine the questions in a correct sequence.

Table 4.5. Example of Teacher Interaction with Students at the Beginning of the Whole-Class Discussion in MLABIP

Turn	**Speaker**	**Utterance**	**Teacher Question Type**	**Student Cognitive Operation**
22	Teacher	Do these look like each other?	Close-ended (Verification)	
23	Student 1	No, they don't.		Level II (Claim)
24	Teacher	In which features do they differ?	Open-ended (Comparison)	
25	Student 2	Teacher, this thing has a head and body.		Level I (Observation)
26	Teacher	This has a head and body. What was the name of this?	Close-ended (Feature Specification)	
27	Student 2	Sperm. The other has got an egg.		Level I (Compare)
28	Teacher	But you called this as an egg, didn't you?	Meta-cognitive (Need Clarification)	
29	Student 2	It is ovarian. Teacher, does it have another name?		Level II (Clarifications)
....				
47	Teacher	Does everyone agree with your friend? Why do they differ? You said that one has a shape of round, other looks like a snake. Although both of them is inside the human bodies, what is the reason for this difference?	Meta-cognitive (Group Dynamics), Open-ended (Causal Antecedent),Open-ended (Causal Antecedent)	
48	Student	One is male, the other is female.		Level I (Compare)
49	Teacher	What is the reason that male has got this shape and female has got a different shape? What can be the function of this tail?	Open-ended (Causal Consequence), Open-ended (Interpretational)	
50	Student	The tail leads to moving.		Level II (Clarifications)
51	Teacher	It leads to moving. How do you know that sperm is moving?	Open-ended (Judgmental)	
52	Student	Teacher, I had made a research on it.		None

Table 4.5 (Continued)

Turn	**Speaker**	**Utterance**	**Teacher Question Type**	**Student Cognitive Operation**
98	Teacher	Are they cells?	Close-ended (Verification)	
99	Student 1	Yes, they are cells.		Level II (Claim)
106	Student 2	I think both of them are cells.		Level II (Claim)
107	Teacher	Does everyone agree that these are cells?	Meta-cognitive (Group Dynamics)	
108	Student 1	I have changed my mind. For instance, if it is a cell, a baby cannot grow inside it. If it is not a cell, a baby grows. The egg must have role to give a birth to a baby.		Level III (Deduction)
113	Teacher	What can be the role of egg in reproduction? Your friend said that if it is a cell, baby cannot grow inside it. Does everyone agree with her? Do you know how baby is produced?	Open-ended (Interpretational),Meta-cognitive (Group Dynamics), Open-ended (Interpretational)	
114	Student 3	Hakan said that the baby cannot grow inside a cell. But the egg of ostrich is a cell and baby ostriches are grown inside this egg cell. Then, how could this happen?		Level III (Argumentation)
122	Student 4	Teacher, I agree with her. If a baby can grow in an ostrich cell, it grows easily in a human cell.		Level III (Argumentation)

*Level I, Level II, and Level III cognitive operations refer to low, medium, and high cognitive operations respectively.
*Turn indicates the line order of the utterance in the transcript.

The teacher in her MLABIP and HLABIP followed the question sequence in a way that first, she applied the close-ended and open-ended questions, and then used all types. At the end of the whole-class discussion majority of teacher questions were in metacognitive type.

4.2 Case Study of Teacher B

4.2.1 Comparison of Question Types between Medium and High-level ABI Implementations

The distribution of teacher question types by implementation level is provided in Figure 4.2. As seen in the figure, the teacher asked more questions in his medium-level implementation. However, a Chi-square analysis indicated that there is not any significant difference between the total number of questions asked in MLABIP and HLABIP, X^2 (1, N = 203) = 3.08, p = .079.

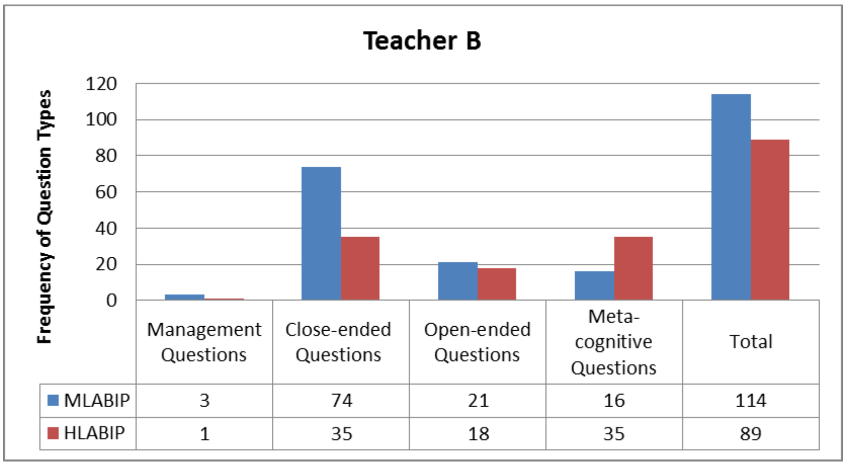

Figure 4.2 Distribution of Teacher Question Types by Implementation Level-Teacher B

By analyzing the relationship between teacher question type and implementation levels, a Chi-square test revealed that teacher question types significantly differ between MLABIP and HLABIP, p = .000

As seen in Figure 4.2, the teacher used close-ended questions as the most in MLABIP. The most frequently used questions types were meta-cognitive and close-ended questions in HLABIP. The least frequently asked questions were management questions both in MLABIP and HLABIP. The number of management questions is very few in both levels. This total number does not ensure the assumption of Chi-square analysis which states that the lowest frequency in any cell should be 5 or more (Pallant, 2005). Since the assumption violated, management questions were not included in the further analysis of Chi-square test.

The detailed frequency and percentage scores of each question type for MLABIP and HLABIP are given in Table 4.6. The scores in the table are interpreted within the following categories: close-ended question comparisons, open-ended question comparisons, and meta-cognitive question comparisons. As was mentioned before, since management questions do not ensure the statistical comparison of Chi-square test, it is extracted from the analysis.

4.2.1.1 Close-ended Question Comparisons

The frequency of close-ended questions decreased in the HLABIP. A Chi-square test indicated a significant decrease in the frequency of close-ended question type, X^2 (1, N = 109) = 13.95, p = .000. When examining the proportions of sub-types of questions, the differences appear to emerge from the verification, feature specification and concept completion questions. Teacher did not ask any quantitative questions in both implementation levels. The frequency of disjunctive questions showed increase in the HLABIP (See Table 4.6).

Table 4.6. Frequency and Percentage of Questions from Each Type for Each Implementation Level-Teacher B

Question Category	**Teacher B**			
	MLABIP		**HLABIP**	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Management Questions	**3**	**2**	**1**	1
1. Request/Directive	2	2	0	0
2. Monitoring	1	0	1	1
Close-ended Questions	**74**	**65**	**35**	**40**
3. Verification	38	33	18	20
4. Disjunctive	6	5	10	12
5. Concept Completion	12	11	2	2
6. Feature Specification	18	16	5	6
7. Quantification	-	-	-	-
Open-ended Questions	**21**	**19**	**18**	**20**
8. Definition	2	2	1	1
9. Example	-	-	1	1
10. Comparison	5	5	-	-
11. Interpretational	1	0	7	8
12. Causal Antecedent	1	0	4	5
13. Causal Consequence	4	4	3	3
14. Enablement	6	6	-	-
15. Expectational	2	2	2	2
16. Judgmental	-	-	-	-
Meta-Cognitive Questions	**16**	**14**	**35**	**39**
17. Group Dynamics	2	2	12	14
18. Self-directed learning	1	0	5	5
19. Need Clarification	13	12	18	20
TOTAL	**114**	**100**	**89**	**100**

4.2.1.2 Open-ended Question Comparisons

There is not any significant difference in the frequencies of open-ended questions asked between the MLABIP and HLABIP. While the percentage accounts for 19% of all questions asked in medium-level, it increased to 20% in the high one. When looking at the percentages of sub-types of open-ended questions in detail, it is seen that the Teacher B did not ask any judgmental questions in both implementation levels. Similarly, the frequencies of definition, example and expectation questions are in negligible values (See Table 4.6).

4.2.1.3 Meta-cognitive Question Comparisons

The teacher use of meta-cognitive questions increased in the HLABIP. By examining the statistical difference of the frequencies, a Chi-square test indicated a significant increase of the question type in the high implementation level, $p = .008$. The increase in the question type appears to emerge from the increase in all sub-types which are group dynamics, self-directed learning and need clarification.

4.2.2 Comparison of Multiple Questions between Medium and High-level ABI Implementations

Teacher B used a series of questions strung together in a similar frequency in MLABIP and HLABIP. However, the percentage of multiple question string is around 8% of all questions both in MLABIP and HLABIP. The teacher mostly used multiple string questions in order to extend what he meant in the initial question and/or narrow the range of answers of students. See the below representative examples of multiple question strings of Teacher B in Table 4.7.

Table 4.7. Example of the Teacher Use of Multiple Question Strings in MLABIP-Teacher B

Actual Conversation			
Speaker	**Utterance**	**Question Type**	**Comments**
Teacher	So then, which variable is greater in the lemon peels? Is the mass or volume greater in lemon peels?	CC	The teacher asks a close-ended question and continues with further close-ended type. He repeats the initial questions in an attempt to clarify what he meant.
Student 1	The mass	-	
Student 2	The volume	-	
....			
Teacher	In order to be able to decide whether an object can float or not, which features do we need to know regarding the object? Since you mentioned about a lemon, call this object a lemon. In order to decide on whether it floats or not, which features of the lemon should be measured?	CC	Teacher asks a question then, specifies what he meant in order to narrow the range of student answers.
Student	Teacher we find the mass and volume of it by observing its surface area.	-	

* "C" refers to close-ended question types.

4.2.3 Relationship between Teacher Questioning Patterns and Student Cognitive Operations in Medium and High-level ABI Implementations

The frequencies of student operation levels are given for each question type and each implementation level in Table 4.8. As shown in the table, while student medium-level cognitive responses were mostly encouraged by teacher close-ended questions, high-level cognitive responses were usually resulted from meta-cognitive type in both implementation levels. Teacher questions initiated a few student responses in low cognitive level.

Table 4.8. The Distribution of the Cognitive Level of Student Answers for Each Question Type and Each Implementation Level-Teacher B

Teacher Question Type	MLABIP			HLABIP		
	Cognitive level of the Student Answer			Cognitive level of the Student Answer		
	Level I	Level II	Level III	Level I	Level II	Level III
Management	-	1	-	-	-	-
Close-Ended	3	35	3	1	17	4
Open-Ended	2	10	-	1	9	3
Meta-Cognitive	2	6	5	2	11	13

The data given in Table 4.8 provides additional evidence on why the present study revised the taxonomy of questions types. As described previously, in the taxonomy of question types, the high-level questions were determined as to be open-ended type. However, as seen in above table, open-ended question types could not achieve to initiate higher level responses as much as meta-cognitive questions. In both MLABIP and HLABIP, most of the student high-level responses were initiated by meta-cognitive questions.

The second revision in the taxonomy of question types was the separation of meta-management question type as management and meta-cognitive question categories. The reason to make this distinction was the different purposes that these two types serve. Teacher B used only few management questions in his both implementation levels such as "Which group wants to come first to present their works? Do you listen to your friends" but all gave request for action to students. The meta-cognitive questions were mostly involved in initiating student practice of higher-level skills in both implementation levels (See Table 4.8).

In HLABIP, at the beginning of the whole-class discussion, the teacher frequently asked open-ended and close-ended questions in order to create conceptual conflict in student understanding of the topic (See Table 4.9). He applied very few meta-cognitive questions at this process. Students involved in short answers in reply to open-ended and close-ended questions asked at the beginning of the lesson. The following figure shows the examples of teacher questions and student short answers taken place at the beginning of the lesson in HLABIP.

Table 4.9. Example of Teacher Interaction with Students at the Beginning of the Whole-Class Discussion in HLABIP

	Actual Conversation			
Turn	**Speaker**	**Utterance**	**Teacher Question Type**	**Student Cognitive Operation**
1	Teacher	How do people establish a communication with each other?	Open-ended (Interpretational)	
2	Student 1	Teacher, with voice		Level II (Claim)
3	Teacher	They communicate thanks to voice. Then, how do humans create a voice to be able to communicate each other?	Open-ended (Interpretational)	
4	Student 2	By vibrating the vocal cords.		Level II (Clarifications)
5	Teacher	By vibrating the vocal cords. Well, why the vocal cords vibrate while talking?	Open-ended (Causal Antecedent)	
6	Student 3	Sound waves.		Level II (Claim)

Table 4.9 (Continued)				
	Actual Conversation			
Turn	**Speaker**	**Turn**	**Speaker**	**Turn**
7	Teacher	Do the sound vibrations cause sound waves or sound waves cause vibrations?	Close-ended (Disjunctive)	
8	Student 4	Vibrations cause sound waves.		Level II (Claim)
9	Teacher	Yes, Zehra.	-	
10	Student 3	Teacher our talking results in vibration of the cords.		Level II (Clarifications)

*Level I, Level II, and Level III cognitive operations refer to low, medium, and high cognitive operations respectively.
*'Turn' indicates the line order of the utterance in the transcript.

As shown in Table 4.9, the teacher frequently used close-ended and open-ended question types with the aim of challenging student conceptual knowledge. Student responses usually included short answers requiring specific information. When the teacher started to ask meta-cognitive questions around the fifth minute of the whole-class discussion, students still gave content-based short answers to teacher questions. In order to trigger student higher cognitive operations, the teacher supported his meta-cognitive questions by asking open-ended and close-ended questions. At this stage, the teacher mostly applied multiple string questions covering all question types (See the examples provided in Table 4.10).

Table 4.10. Example of Teacher Interaction with Students at the Whole-Class Discussion in HLABIP

	Actual Conversation			
Turn	**Speaker**	**Utterance**	**Teacher Question Type**	**Student Cognitive Operation**
75	Teacher	Well, how do the sound waves travel through the air? You observed its moving in the water. Does it have the same attitude in the air?	Open-ended (Interpretational), Close-ended (Verification)	
76	Student 1	It goes to all directions, it is scattered.		Level II (Claim)
77	Teacher	It goes to all directions. Its attitude is similar with that of water. Does everyone think like that?	Meta-cognitive (Group Dynamics)	
78	Student 2	It moves to all directions.		Level II (Claim)
79	Teacher	Well, for a sound wave travelling, how does it move in the form of a wave? How might it be occur through the matters?	Open-ended (Interpretational), open-ended (Expectational)	
80	Student 3	By vibrating the molecules.		Level II (Clarifications)
81	Teacher	It is still transported in …..	Close-ended (Concept Completion)	
82	Student 3	Not in a linear direction.		Level II (Claim)
83	Teacher	Can the sound travel in a linear direction? What did you mean by stating it is not propagated in a linear direction?	Close-ended (Verification), Meta-cognitive (Need Clarification)	
84	Student 4	The sound propagates in the form of waves. For instance, wherever we are, we can hear the sound of a horn.		Level III (Deduction)
85	Teacher	You meant we can hear it.	-	

Table 4.10 (Continued)

	Actual Conversation			
Turn	**Speaker**	**Utterance**	**Teacher Question Type**	**Student Cognitive Operation**
87	Teacher	Your friend asked that does volume and velocity differ in sound propagation. What do you think on that?	Meta-cognitive (Group Dynamics)	
88	Student 4	I think the strength of the sound is different thing.		Level II (Claim)
89	Student 5	Teacher, I want to answer to her question. When someone talks in a lower voice, his sound waves reduce. Thus, it differs. The increase in sound waves has direct relationship with the intensity of the sound. It can increase or reduce.		Level III (Argumentation)
90	Teacher	What did you mean by the intensity of the sound? What is the definition of it?	Meta-cognitive (Need Clarification), Open-ended (Definition)	
91	Student 5	I meant that it is frequency.		Level II (Clarifications)
92	Teacher	Are the frequency and intensity same things?	Close-ended (Verification)	
105	Student 6	Teacher, frequency and intensity of the sound are very different things. The intensity refers to volume of the sound. If it is too intensive, it is moved in the form of waves. For instance, when we listen to music too loudly, our eardrum can be ruptured. We can understand what intensity is from this example.		Level III (Induction)

*Level I, Level II, and Level III cognitive operations refer to low, medium, and high cognitive operations respectively.
*'Turn' indicates the line order of the utterance in the transcript.

The teacher needed to apply open-ended and close-ended questions before asking meta-cognitive ones. He waited for an opportunity to ask meta-cognitive questions. For instance, in order to be able to support student construction of an argument, he needed to create conceptual conflict by open-ended and close-ended questions and then, addressed this conflict with meta-cognitive questions to challenge student cognitive operations. When students did not involve in higher cognitive operations across meta-cognitive questions, he added more questions covering all question types (See Table 4.10). The meta-cognitive questions were frequently asked at the end of the whole-class discussion by permitting student-student interaction. The final part of the whole-class discussion required students to share their questions, claims and evidence generated in small-group work. The teacher decreased his voice by asking meta-cognitive questions in order to provide students clarify of own investigative decisions as well as encourage of students to interpret each other's investigation processes and products. Below interaction pattern in Table 4.11 provides a representative example regarding teacher decrease of his voice whereas student involved negotiation of ideas with each other at the end of whole-class discussion.

At the end of the whole-class discussion, students were in great interaction with each other as if the teacher was not in the classroom. Students felt free to express their opinions and evaluate each other's questions, claims and evidence. Although the teacher did not involve much in the discussion, student practices of higher cognitive operations were mostly visible in this discussion period. By examining the role of teacher questions to increase student-student interaction in the whole-class discussion, it appears that the teacher encouraged students to clarify own ideas and evaluate each other's opinions by asking questions such as "What did you mean by asking this question, Do you have any questions to your friends, How can you compare your findings with the other group's? Did your findings align with those of others?"

Table 4.11. Example of Teacher Interaction with Students at the End of Whole-Class Discussion in HLABIP

Turn	**Actual Conversation**			
	Speaker	**Utterance**	**Teacher Question Type**	**Student Cognitive Operation**
362	Teacher	Do you have any questions to these group members?	Meta-cognitive (Group Dynamics)	
363	Student 1	They mentioned about living and nonliving beings. Probably, you will get different results when you had observed living beings.		Level III (Argumentation)
364	Student 2	Yes, I said living and non-living organisms. If I had used a living organism.. How could I hear it? I used one of them, didn't I? What I want to test in my question was non-living organism. Could I answer this question, yes!		Level III (Argumentation)
383	Student 3	Siya, in her group presentation, said that why you didn't use a copper wire. Do we have to use a living-organismic? I think, no.		Level II (Clarifications)
387	Student 1	You meant by living organism that for instance why Yusuf has a deep voice. His voice chords are thicker than others so he has such a deep voice. How could you observe this? In their experiment, they likened the nonliving organisms to bottles. When you increased the amount of water in the bottle…		Level III (Argumentation)

Table 4.11 (Continued)

Turn	Actual Conversation			
	Speaker	**Utterance**	**Teacher Question Type**	**Student Cognitive Operation**
389	Teacher	I will say something. Did Zehra mean that increasing the amount water resembles to increase the proportion of the intensity of the sound? When the voice is getting deeper in the bottle, it becomes deeper.	Meta-cognitive (Need Clarification)	
390	Student 4	When we go to a doctor, what does he say to us? He says that your vocal cords have become thin.		Level II (Clarifications)

Even though the teacher asked close-ended and open-ended questions at the end of whole-class discussion, the student gave responses in high cognitive level operations.

Meta-cognitive question type was not always categorically better than other types to initiate higher cognitive student responses. Close-ended and open-ended questions were also effective for students to practice higher cognitive operations. However, when teacher asked close-ended and open-ended questions in MLABIP, it did not initiate high cognitive level student responses as much as those initiated in HLABIP. Although the total number of close-ended and open-ended questions asked in MLABIP is higher than HLABIP, student high cognitive level responses to those types were fewer in MLABIP.

By examining the reason behind this situation, it appears that the teacher did not apply meta-cognitive questions at the end of whole class discussion as much as those in HLABIP. The frequent use of meta-cognitive questions at the end the whole-class discussion in HLABIP may have provided opportunities to students feel free to negotiate each other's ideas. In case of this, student high-level cognitive operations sparked once and then, the teacher question type had little impact on student high cognitive level.

4.3 Cross-case Analysis Results of Two Cases

This section will determine the similarities and differences of the findings of the two cases by applying cross-case analysis. A cross-case analysis provides data interpretation through analysis of the similarities and differences in and between cases (Merriam, 1998). As a reminder, the needs of this study were best suited to a multiple case study design. This design was preferred since it was matched with many of the methods to collect and analyze data, and to present the findings of this study. The cross-case analysis as part of the multiple case design aims to indicate similar and different characteristics of the results from multiple cases. While "the differences between the cases do lend interest to each individual case" (p. 159), the similarities contribute to the focus of research questions (Harootunian, 2007).

4.3.1 Research Question 1

The cross-case analysis for research question 1 did not indicate any difference between the cases. The shared similarities between the questions types of Teacher A and Teacher B across medium and high implementation level is provided below.

The teachers mostly used close-ended question type in high-level practices; however, there were very few percentage differences between close-ended and meta-cognitive question types. These two question types did not significantly differ in their frequency. Teachers needed to apply similar proportions of close-ended and meta-cognitive questions in their high quality classrooms. When taking the average of the percentage of question types used by two participants, it was evident that in the high quality classrooms, teachers applied 39% close-ended questions, 36% meta-cognitive questions and 20% open-ended questions. The percentage of management question type was too low when compared to other types.

Comparing the medium and high-level ABI classrooms, it was evident that teachers' close-ended questions significantly decreased while meta-cognitive questions significantly increased in the high quality the classrooms. There was not any significant change in the number of open-ended and management questions. The main difference in teacher use of question types between medium and high quality implementations was observed in decreased percentage of close-ended questions and increase percentage in meta-cognitive question type.

Although not part of the research question, the total number of questions asked in the medium and high-level practices were tallied. The results of the analysis revealed that the teachers in MLABIP asked more questions than in HLABIP; however, this difference in the frequencies of questions does not show statistical significance.

4.3.2 Research Question 2

In high-level practices, teachers frequently used open-ended and close-ended questions at the beginning of the lesson in order to create conceptual conflict in student understanding of the topic. They used very few meta-cognitive question types at this class period. Students provided short answers in reply to open-ended and close-ended questions asked at the beginning of the lesson. The teachers needed to use open-ended and close-ended questions before asking meta-cognitive ones. They waited for an opportunity to ask meta-cognitive questions. In order to be able to support student construction of an argument, they needed to create conceptual conflict by open-ended and close-ended questions and then, addressed this conflict with meta-cognitive questions to challenge student high-level practices. When students did not involve in higher cognitive practices across meta-cognitive questions, they added more questions covering all question types. The meta-cognitive questions were frequently asked at the end of the whole-class discussion by permitting student-student interaction. The final part of the whole-class discussion required students to share their questions, claims and evidence generated in small-group work. The teacher decreased his voice by asking meta-cognitive questions in order to provide students clarify of own investigative decisions as well as encourage of students to interpret each other's investigation processes and products.

Teachers in their medium-level practices followed the similar question sequence with the high-level implementations in a way that first, they applied to close-ended and open-ended questions, and then used all types together. At the end of the whole-class discussion majority of teacher questions were in metacognitive type. While these three question types followed a specific sequence in teacher questioning, management questions were asked randomly by the teachers. There was not any specific order of management questions.

In both medium and high-level classrooms, meta-cognitive questions have the most potential among all to initiate student practice of high-level skills such as induction, deduction and argumentation. This is the reason why the present study underwent a revision in the taxonomy of question types that developed by Graesser and Person (1994). The original taxonomy identified higher-level questions as to be open-ended type in which students are usually required to organize, compare and interpret information (Graesser & Person, 1994). Within the scope of the present study, a total of 587 questions were examined in relation to student response levels and was found that open-ended question type was failed to involve students in practicing complex skills such as induction, deduction, and argumentation. The present study empirically revealed that it was meta-cognitive question type to involve student practice of these complex skills. While approximately 50% high-level response in medium-level classrooms of both teachers was promoted by meta-cognitive questions, this percentage was nearly 63% in high quality classrooms.

Additional revision was made by separating meta-management question type into two distinct categories, which are meta-cognitive questions and management questions. The reason behind this distinction lied behind different purposes that these two question types serve. While meta-cognitive type including group dynamics, self-directed learning, and need clarification questions, had the most potential to initiate high-level response and to increase student-student interaction, management question type least frequently occurred in high-level response. Management questions served to manage or understand student physical directions while students are engaging in assignments or experiments in the classrooms.

Lastly, the present study revealed that meta-cognitive question type was not always categorically better than other types to initiate higher cognitive student responses. That is, it was not always evident that all the meta-cognitive questions initiated high-level response. Especially, at the beginning of the whole-class discussions, even though the teachers asked meta-cognitive questions, they received responses in lower cognitive levels. In case they structured the discussion on a particular sequence, the meta-cognitive questions started to engage students in higher-level responses. As mentioned previously, this particular sequence mostly required asking of first open-ended and close-ended type, then using meta-cognitive questions. Moreover, close-ended and open-ended questions were also effective for students to practice of higher cognitive operations. Especially, at the end of whole-class discussion, when the teachers asked close-ended or open-ended question type, they received a response in high cognitive levels. Student high-level cognitive operations sparked once and then, the teacher question type had little impact on student high cognitive level. However, teacher close-ended and open-ended questions asked in MLABIP did not initiate high cognitive level student responses as much as those initiated in HLABIP. The total number of close-ended and open-ended questions asked in MLABIP is higher than HLABIP, but student high cognitive level responses to those types were fewer in MLABIP.

CHAPTER 5

DISCUSSION

This chapter will discuss the findings of this study in the light of related research in education literature. First, the characteristics of teacher question types used in high quality classrooms will be discussed and then, teacher questions asked in high quality classrooms will be distinguished from those posed in medium quality classroom practices. By discussing teacher questioning in high and medium quality practices, readers may make sense of distinguishing characteristics in the improvement of questioning strategies. Secondly, the sequence of question types promoting higher level student responses will be discussed in high quality classrooms by comparing it with those used in medium quality practices. Then, the chapter will address limitations and implications of the study, respectively.

5.1.1 Discussion of the Findings

Prior to discuss the findings of the study, it is significant to remember what was revealed in the cross-case comparison. The findings of the cross-case comparison did not reveal any difference between the cases (teachers). Thus, the discussion of the findings will focus on the convergent results driven from the cases.

The present study attempted to delineate the characteristics of teacher pedagogic development in ABI teaching through questioning. The characteristics of teachers' different implementation levels of ABI teaching (middle and high) were described based on questioning since research in this area suggest a strong relationship between teacher implementation levels and questioning behaviors in science classrooms. Teachers' use of specific questioning strategies is a significant factor affecting their pedagogic development in science classrooms (Benus, Yarker, & Hand, 2010; Martin & Hand, 2009; McNeill & Pimentel, 2010; Oliveira, 2010; Pimentel, Katherine, & McNeill, 2013). This significance arises from the role of questioning in such as increasing student talk (Gunel, Kingir, & Geban, 2007; Martin & Hand, 2009), starting and guiding the classroom negotiation (Gunel, Kingir, & Geban, 2007; Kawalkar & Vijapurkar, 2013), implementation of scientific argument (Martin & Hand, 2009); improving reasoning and justification for explanations (Benus, Yarker, & Hand, 2010), all which are key features of ABI classrooms (Piburn et all., 2000). Whereas in high quality ABI classrooms, teacher questioning closely serves to above mentioned purposes, questions those asked in medium-level implementations, serve to more traditional transmission of knowledge compared to high-level implementations. Thus, it attaches significance to look insight into the teacher questioning in high-level ABI implementations in order to characterize high quality questioning.

This study characterized teacher questioning in high quality classroom implementations by comparing it with that used in medium-level classroom practices. The reason to make the comparison of teacher questioning between medium and high quality classrooms lied behind not only delineating the features of high quality questioning but also providing insight into the differences occurred when teachers attempted to improve their questioning. In education literature, there are various considerations to assess or improve teacher quality of questioning. One of these considerations and the most favorable one is examining teacher question types based on the type of cognitive process it requires (Gall, 1970). In these studies, although effective question type is determined as to be open-ended or high-level questions, it is mostly found that teachers pose predominantly cognitive-memory or factual-recall questions (Cunningham, 1977; Dantonio & Beisenherz, 2001; Gall, 1970; Graesser & Person, 1994; Greenough, 1976; Hamm & Perry, 2002; Newton & Newton, 2000; Yip, 2004).

In an attempt to improve teacher questioning skills, several research implemented teacher training programs and found that teachers asked more higher-level questions than lower-level ones after the treatment (e.g., Erdogan & Campbell, 2008; Martin & Hand, 2009). Several research (e.g., Goodwin et al., 1983; Konya, 1972), on the other hand, observed that it may not be necessarily required to use higher level questions more frequently than lower level types, but teachers should use question types in particular proportions (e.g., 50% close-ended and 50% open-ended type). High-level questions are widely accepted to be categorically better to promote high-level student thinking but it is controversial in the literature whether teachers need to use more higher-order questions in a classroom.

By examining the characteristics of the questioning in high quality ABI classrooms, this study observed that the teachers mostly used close-ended type (lower-order questions); however, meta-cognitive type (higher-order questions) was nearly as dominant as close-ended questions. The frequency of close-ended questions was higher than meta-cognitive type but this difference did not indicate statistical significance. In other words, the teachers applied similar frequencies of close-ended and meta-cognitive questions in their high quality classrooms. When taking the average of the percentage of question types used by two participants of the study, it was evident that the teachers applied 39% close-ended questions and 36% meta-cognitive questions. While the percentage of open-ended question type (20%) was significantly lower than the close-ended and meta-cognitive questions, the management questions were the least frequently used question type. The teachers did not use management questions in considerable percentages when compared to types in high quality classrooms.

These findings concur with those stating that it does not necessarily require using higher level questions more frequently than lower level ones to initiate high-level student thinking (e.g., Goodwin et al., 1983; Konya, 1972). Similar to the present study's findings, by examining teacher quality of questioning based on student responses, Konya (1972) revealed that in the classrooms where students were exposed to similar proportions of higher-level and lower level question types were the most effective in initiating student high-level response. However, most of the research in education literature (e.g., Erdogan & Campbell, 2008; Katherine, McNeill, & Pimentel, 2009; Oliveira, 2009) found that teachers in high quality classrooms posed much more high-level questions than low-level ones. Since the findings of the present study do not concur with what most of the research in this area found, further attempt was made in order to provide insight into the reason behind teacher use of similar proportions of low-level and high-level question types.

In this attempt, the researcher of the present study examined when and with which purposes that teachers used different question types. As Gall (1984) asserted that "Teachers' questions that require students to think independently and those that require recall of information are both useful but serve different purposes. The challenge for teachers is to use each type to its best advantage" (p. 41). Gall suggested that high-level question types categorically better than others to initiate thinking skills but it does not necessarily mean that other question types are useless. The qualitative analysis into teachers' timing and purposes to use various question types revealed much more than what Gall suggested. The present study observed that lower-level questions created a ground to ask for high-level questions. The participating teachers in their high-level practices used close-ended and open-ended question types in order to be able to ask meta-cognitive questions. The teachers needed to use open-ended and close-ended questions before asking meta-cognitive ones; they waited for an opportunity to ask meta-cognitive types. For instance, in the high quality classrooms of both Teacher A and Teacher B, the teachers used frequently meta-cognitive questions for the first time around 7^{th} minute of the whole-class discussion. Up to this minute, they mostly asked questions in open-ended and close-ended types. In order to be able to support student practice of high cognitive skills, teachers needed to create conceptual conflict by open-ended and close-ended questions and then, addressed this conflict with meta-cognitive questions to challenge student high-level practices. The sequence of teacher question types is detailed below in the section. At this point, it is important to emphasize that the teachers' frequent use of close-ended questions might arise from the need to create a ground to be able to ask for meta-cognitive questions. As Gall suggested, close-ended or other question types should be used in order to meet their best advantages and this study observed that close-ended or factual questions served as a 'pawn' to be able to challenge student higher-level cognitive practices.

Factual questions in this study refer to close-ended type which requires verification, disjunctive, concept completion, feature specification and quantification in response. Overall, it expects students to give specific information in answer (Graesser & Person, 1994). The definition of factual questions in this study concurs with all other research definitions. However, meta-cognitive question type has distinctive description compared to those of other studies. While there has been a consensus on the definition of high-level questions as which require student practice of high-level skills, the definition of these skills have varied in the education literature throughout time. This study adopted the types of high-level cognitive skills emerged in the study of Grimberg and Hand (2009) in a classroom facilitating with ABI approach. The high-level thinking skills emerged in this study, which are induction, deduction, investigation design, and argumentation, are congruent practices with what science reform movements suggest (Grimberg & Hand, 2009). In the specification of high-level cognitive skills, several researchers (e.g., Amer, 2006; Furst, 1994; Sugrue, 2002) call for the requirement of complex skills concurring with reform movements by reviewing the accessible taxonomies of cognitive operations. This is one of the reasons why this research underwent a revision of taxonomy of question types developed by Graesser and Person (1994).

In the taxonomy of question types, high-level questions are determined as to be open-ended type in which students are usually required to organize, compare and interpret information (Graesser & Person, 1994). Within the scope of this study, a total of 587 questions were examined in relation to student response levels and found that open-ended question type was failed to involve students in practicing complex skills such as induction, deduction, and argumentation. This study empirically revealed that it was meta-cognitive question type to involve student practice of these complex skills. The categories under meta-cognitive questions, which are group dynamics, self-directed learning, and need clarification, were emerged in the study of Hmelo-Silver (2003). The researcher revised the original taxonomy of question types that developed by Graesser and Person (1994) by frequently observing these additional question types. While Hmelo-Silver (2003) grouped these additional three categories under a meta-management question type, the researcher of this study separated meta-management category into two as meta-cognitive questions and management questions, since the findings revealed that they served to different purposes in the classrooms. While meta-cognitive type including group dynamics, self-directed learning, and need clarification questions, had the most potential to initiate high-level response, management question type least frequently occurred in high-level response. Management questions served to manage or understand student directions while they are engaging in assignments or experiments in the classrooms but its frequency was too low in both medium and high-level classrooms.

High-level student response was mostly initiated by meta-cognitive questions. While approximately 50% high-level response in medium-level classrooms of both teachers was promoted by meta-cognitive questions, this percentage was nearly 63% in high quality classrooms. This difference can be explained with increase number of meta-cognitive questions in high-level classrooms. Additionally, students in medium-level practices for both cases mostly involved in medium-level cognitive operations (conception level) in answer. The dominant cognitive skills in high-level practice, on the other hand, were showed difference between two cases. While in the high-level class of Teacher A, students mostly practiced high-level cognitive skills (abstraction level), students in the high-level class of Teacher B were mostly engaged in medium-level cognitive skills (conception) in the answer. The frequency of meta-cognitive questions is higher in the class of Teacher A than Teacher B's. The reason behind the dominance of medium-level cognitive skills in the class of Teacher B can be explained with the relatively low frequency of meta-cognitive questions when compared to the class of Teacher A. However, in both classrooms, there was not huge difference between medium-level and high-level cognitive skills in the answer.

This study examined question type of teachers by comparing their medium and high quality ABI classroom practices. Different quality implementations were achieved throughout a longitudinal (3-year) PD program. While medium quality corresponded to 3rd implementation semester (18th month) of ABI, high quality occurred in 4th implementation semester (24th month) in the 6-semester PD program. The focus on these semesters has significance in terms of achieving permanent shift in teacher pedagogic practices. Gunel and Tanriverdi (2012) reported that the changes in teacher pedagogic practices remain permanent after the 18 months of a longitudinal training period. Teachers need to be trained at least 18 months in order to observe significant shifts in their pedagogic practices (Martin & Hand, 2009; Tanriverdi & Gunel, 2012). In this regard, the findings of this research attach distinctive significance when compared to those others revealed at short-term PD programs. It is significant to note that research on improving teacher pedagogic practices was widely conducted in short-term PD programs (Darling-Hammond, 2005; Darling-Hammond & McLaughlin, 1995; Lieberman, 1995; Shibley, 2006; Xu, 2002).

Comparing the medium and high-level ABI classrooms, it was evident that teacher close-ended questions significantly decreased while meta-cognitive questions significantly increased in the high quality the classrooms. There was not any significant change in the number of open-ended and management questions. The main difference in teacher use of question types between medium and high quality implementations was observed in decreased percentage of close-ended questions and increase percentage in meta-cognitive question type. The decrease in close-ended question type after teacher underwent training was evident in many studies (e.g., Bolen 2009; Erdogan & Campbell, 2008; Martin & Hand, 2009; Storey, 2004). There is not any accessible study observing increase in close-ended questions after teacher training in questioning skills. Similarly, it was found in all of these studies that teacher use of high-level questions increased after the training. However, as mentioned previously, these studies addressed high-level question as to be in open-ended type which require extended answers rather than involving in one specific answer. Within the scope of the current study, high-level question referred to a new category, which is meta-cognitive type. The requirement of a new question type was emphasized by Gall (1970) stating that many of the question classification systems were constructed based on investigation of teacher question types which actually observed in a classroom rather than considering the types of questions which teacher should use. The researcher made this assertion in order to give insight into the inefficiency of classification systems to assess actual high-level teacher questions. Moreover, he argued teacher insufficiency to apply higher cognitive questions in a way that even though teachers apply these questions, the current taxonomies may not be able to assess these levels. Although this assertion was given in 1970s, most of the question classification taxonomies based on cognitive foundations revealed by Bloom and his colleagues at 1960s. By defining an additional category of meta-cognitive type as suggested by Hmelo-Silver (2003), this study may have significant contribution in research literature examining effective teacher question type.

Although examining teacher question types tell much about teacher questioning behavior to initiate cognitive processes that students engage in (Chin, 2007; Gall, 1970; Pate & Bremer, 1967), they should not be investigated as isolated from each other (Gall, 1970; Taba, 1966). In this manner, this study examined sequences of teacher question types in medium and high-level practices to promote high-level student responses. This sequence required to examine the order of questions types as suggested by Taba (1966). The findings revealed that in both medium and high-level practices, the teachers needed to apply open-ended and close-ended questions before asking meta-cognitive ones. They created a conceptual conflict by open-ended and close-ended questions and then, addressed this conflict with meta-cognitive questions to challenge student high-level cognitive operations. When students did not involve in higher cognitive operations across meta-cognitive questions, the teachers added more questions covering all question types. The meta-cognitive questions were frequently asked at the end of the whole-class discussion by permitting student-

student interaction. Similarly, by analyzing studies on classroom questioning Gall (1970) cautioned that some educators believed on the need to direct classroom discussion first by asking recall questions and then to manipulate ideas with higher cognitive question. The recall questions will serve to test knowledge of facts while higher-level questions challenge student thought on this knowledge. In an attempt to describe questioning strategies that initiate students to reflect on curriculum materials at abstract levels of thought, Taba (1966) suggested to apply this sequence to promote high-level thinking in students. Although the need for examining the sequence of question types was emphasized by the research review of Gall (1970) a few decades ago, studies did not give attention to this issue. The researcher of this study could not access any study focusing on the sequence of teacher question types. This is particularly supported with a research review in a recent time conducted by Cotton (2001) in a way that he did not report any study concerning the question sequence in an attempt to analyze characteristics of research on classroom questioning.

Even though not part of the research questions, this study also attempted to compare the total number questions asked in medium and high-level practices since it is controversial whether there is a relationship between total number of questions asked by teachers and quality of classroom practice. While several researchers found that teachers asked fewer questions in high quality classrooms compared to low level practices (e.g., Martin & Hand, 2009; Tobin, 1987), others observed an increase in this number (e.g., Erdogan & Campbell, 2008; Oliveira, 2010). While opponents of the need for decrease explained it with the changing focus of high quality classroom from teacher-oriented to more open discursive practices (Martin & Hand, 2009), and with increase amount of student talk (Martin & Hand, 2009; Tobin, 1987), Erdogan and Campbell (2008) related the increase number with an active role of teacher in constructivist learning environments. In this manner, Gadamer (1993) argued that number of questions asked by teachers do not much matter since a question focusing on a particular thinking can be more effective than a hundred questions requiring only the recall of facts. Additionally, Schreiber (1967) cautioned that the number of questions asked during a classroom varies teacher to teacher. Although above mentioned studies did not control teacher factors as suggested by Schreiber, they revealed particular relationships. This study observed the same teacher in different time periods, thus controlled the teacher factor. In this context, this study found a decrease in the total number of questions asked by teachers when they improved classroom practices from medium to high-level but this difference did not show statistical significance.

Additionally, this study observed that besides asking individual questions, the teachers posed a series of questions, which were not interrupted by student responses, both in medium and high-level practices. These questions were referred as multiple question strings by Fink (1987). The frequency and length of multiple strings were not differed in the teachers' medium and high-level practices. Moreover, the number of individual questions was much greater than multiple question strings in both medium and high practices. Multiple question strings are associated with teacher use of short wait time (Fink, 1987). Researchers argue for the need to provide some wait time between any two questions, otherwise teacher will involve in asking multiple string questions. White and Lightbrown (1984) observed that multiple questions resulted in repetitive questions that rephrase the initial one and teacher's use of wait time decreased the frequency of repetitions. Although there are several critiques on using multiple questions since they involve in repetition of questions, this study observed that multiple string questions were mostly used in order to narrow the range of student answers. The teacher asked a question, and she needed to ask another question in order to clarify the meaning in the focus of question or narrow the options in student responses.

5.1.2 Limitations

As similar to any other case studies, findings are limited by the context and individual characteristics of the classrooms. Examining a different set of participants might have shown different findings. As indicated before, the sample selection was convenient and purposeful processes with the intent of achieving teachers those facilitated different implementation qualities of ABI teaching within the context of the professional development program. This study achieved teachers having medium and high quality practices; however, low level practices could not be attained due to the unavailability of the video recordings. There was a limited availability of the taped data from the teachers' low level classroom practices. Additionally, the study investigated data from whole-class discussion since the video recordings from small-group discussions had limited recordings. The quality of these videotapes was too low to catch most of the views in the classrooms. The technical problems such as unclear audio, frozen image, or image without audio in small group discussions limited the data. The lack of data from small-group discussions limits observations in terms of other questioning behaviors.

5.1.3 Implications of the Study

As the reform movements suggest ABI practices in science classrooms, it may be significance to take a closer look into these classrooms. As Patton (1987) suggested that it is important to describe teaching mechanisms of teachers as they implement effective classroom practices. In this regard, the present study provides cases rich in information to teachers and researchers on the characteristics of questioning associated with high quality ABI learning environments. In education literature, although effective teacher question types were mostly determined as those initiating high cognitive level practices in response, it is controversial what proportions of question types should be used for high quality questioning. The present study observed within each case that teachers applied similar proportions of low and high-level question types. Moreover, they increased the use of high-level questions and decreased the low-level question types while improved their teaching implementations from medium to high-level. Comparison of the teacher use of question types as well as questioning patterns between medium and high-level practices contributes to readers understanding on the differences occurred when teachers attempted to improve their questioning.

By investigating the cognitive correspondence between a total of 587 teacher questions and student responses to each question, this study observed that it was meta-cognitive question type to initiate student higher cognitive level practices such as argumentation, induction, and deduction. Although the related research mostly addressed open-ended questions to have the most potential in increasing student high cognitive practices, the present study empirically found that open-ended questions failed to engage learners in such practices. The requirement of a new question type was emphasized by Gall (1970) while the researcher criticized the inefficiency of classification systems to assess actual high-level teacher questions. Although this critique was given in 1970s, it still attaches significance since most of the research use Bloom's taxonomy that suggested in 1960s in order to classify questions. Considering above discussed issues, this study can be a pioneer for further studies in an adoption of the meta-cognitive questions as a high-level question type.

5.1.4 Recommendations for Future Research

There are various suggestions for the future research.

1) As mentioned in the limitations part of the study, another group of participants, which include classrooms having different grade levels or socio-cultural backgrounds are warranted.
2) The future research should focus on examining questioning behaviors of teachers those having low quality of implementation as well as medium and high-levels.
3) In order to increase the transferability of the results, it is recommended to replicate this study with a larger sample size.
4) Since the videotapes from small group discussions were in limited availability, future studies should include field observations from the implementations in order to attain depth understanding into teacher questioning.

5) In this study, meta-cognitive question type was empirically found to promote high-level student responses as the most frequently compared the other types. Future studies should also provide empirical evidence on the effect of meta-cognitive question type on student high-level thinking.

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APPENDICES

APPENDIX A

The Modified Reformed Teaching Observation Protocol (RTOP)

		Never Occurred				Very Descriptive
Student Voice	-Instructional strategies respected students' prior knowledge/preconceptions.	0	1	2	3	4
	-Focus and direction of lesson determined by ideas from students.	0	1	2	3	4
	-Students communicated their ideas to others	0	1	2	3	4
	-High proportion of student talk and a significant amount was student to student.	0	1	2	3	4
	-Students' questions and comments determined focus and direction of classroom discourse.	0	1	2	3	4
	TOTAL					/5=
Teacher Role	-Teacher acted as resource person, supporting, and enhancing student investigations.	0	1	2	3	4
	-The metaphor "teacher as listener" was very characteristic of this classroom.	0	1	2	3	4
	TOTAL					/2=
Science Argument	-Students were actively engaged in thought provoking activities that involved critical assessment of procedures.	0	1	2	3	4
	-Students were reflective about their learning.	0	1	2	3	4
	-Intellectual rigor, constructive criticism, and the challenging of ideas were valued.	0	1	2	3	4
	-Active participation was encouraged and valued.	0	1	2	3	4
	-Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.	0	1	2	3	4
	TOTAL					/5=
Questioning	- Teacher questioning triggered divergent modes of thinking.	0	1	2	3	4
	TOTAL					/1=

APPENDIX B

TURKISH SUMMARY

Bireylerin, değişen ve gelişen dünyada, bilimsel ve teknolojik değişimlere ayak uydurabilmeleri için fen bilimleri dersi öğretim programları bilginin depolandığı geleneksel öğretim anlayışlarının yerine bilginin yapılandırılarak öğrenildiği öğrenci merkezli öğretim anlayışlarını benimsemiştir. Değişen bu öğretim anlayışı, bireylerin bilgiyi yapılandırırken yalnızca "keşfetme ve deney yapma" süreçlerinde değil aynı zamanda "açıklama ve argüman kurma" süreçlerinde de aktif rol almalarını ön görmektedir (Milli Eğitim Bakanlığı, [MEB], 2013, s. 3). Benzer şekilde Amerika'da yayınlanan Gelecek Nesil Bilim Standartları (National Research Council, [NRC], 2012) öğrenmenin laboratuvar çalışmalarının yanı sıra müzakere etme gibi sosyal süreçlerle yapılandırılarak gerçekleşmesi gerekliliğini vurgulamaktadır. Gerek ulusal gerekse uluslararası bağlamda ülkelerin fen eğitimi öğretim programları etkili öğrenmenin gerçekleşebilmesi için Argümantasyon Tabanlı Bilim Öğrenme (ATBÖ) uygulamalarını önermektedir.

Fen eğitimi anlayışında meydana gelen bu gelişmeler, öğretmenlerde de önemli pedagojik değişimleri beraberinde getirmiştir. Öğretmen mesleki gelişimi ile ilgili literatür, öğretmenlerin fen eğitimi reformları doğrultusunda öğrenci-merkezli öğrenme ortamları oluşturabilmelerinde soru sorma yöntemlerinin önemli rol oynadığını vurgulamaktadır. Öğretmenlerin soru sorma yöntemleri pedagojik gelişimleri açısından büyük önem taşımaktadır (Benus, Yarker, & Hand, 2010; Martin & Hand, 2009; McNeill & Pimentel, 2010; Oliveira, 2010; Pimentel, Katherine, & McNeill 2013, Pinney, 2014; Promyod, 2013). Etkili ATBÖ ortamları oluşturabilmek için öğretmenler, soru sorma yöntemlerine yönelik bilgi ve beceri geliştirmelidir (Martin & Hand, 2009; Omar, 2004; Pimentel, 2010; Promyod, 2013).

Norton-Meier, Hand, Hockenberry, ve Wise (2008) öğretmen soru sorma yöntemlerinin ATBÖ ortamlarındaki önemine, soruların diyalog tarzı etkileşim oluşturabilme potansiyeline vurgu yaparak değinmişlerdir. ATBÖ sınıflarında öğrenciler, akranları ve öğretmenleriyle aktif müzakere süreçleri içerisinde yer almalıdır. Bu süreç, öğretmenin otorite olarak görüldüğü geleneksel öğrenme ortamlarında tek taraflı (monolog) seyrederken, öğrenmenin dinleyerek ve tartışılarak yapılandırıldığı ATBÖ sınıflarında diyalog şeklinde oluşmaktadır. Öğretmen soruları bu noktada, öğrencilerin etkili diyalog süreçleri içerisine girmesinde önemli rol oynamaktadır (Norton-Meier, Hand, Hockenberry, & Wise, 2008).

Araştırmacılar, öğrenci-merkezli öğrenme ortamlarında etkili soru sorma yöntemlerinin gerekliliğini, soruların sınıfiçi müzakerelerde öğrencilerin payını arttırması (Martin & Hand, 2009); diyalojik etkileşimler oluşturması (Gunel, Kingir, & Geban, 2012); ve öğrencilerin bilişsel becerilerini harekete geçirmesi (Chin, 2007; Oliveira, 2009) ile ilişkilendirmektedir. Öğretmen soruları üzerine yapılan araştırmalar çoğunlukla soruların cevapta talep ettiği bilişsel beceriler üzerine odaklanmaktadır (Cotton, 2001; Gall, 1970).

Öğretmen soruları öğrencilerin bilişsel becerilerini tetikleyen etkili bir faktör olduğundan öğretmenlerin profesyonel derecede etkili sorular sorabilmesi önem arz eder (Gall, 1984). Eğitim literatüründe kaliteli ya da etkili soru sorma yöntemlerini belirleyen birçok ölçüt belirlenmiştir. Bu ölçütlerden biri, öğretmen sorularının cevapta çağrışım yaptığı bilişsel düzey ile ilişkisinin incelenmesidir (Gall, 1970). Öğretmen soru tipleri, bilimsel bilginin yapılandırılma aşamasında, öğrencilerin tecrübe ettikleri bilişsel becerilerin düzeyini belirler (Chin, 2007). Bu bağlamda, etkili soru tipi öğrencide yüksek bilişsel becerileri tetikleyen soru olarak tanımlanırken (Dantonio & Beisenherz, 2001), düşük seviye sorular çoğunlukla bilgi tabanlı çağrışım yapan sorular olarak ortaya çıkmaktadır.

Öğretmen soru sorma yöntemlerinin geliştirilmesi amacıyla birçok çalışma, hizmetiçi eğitim programı uygulamış ve bu çalışmalar program sonrasında öğretmenlerin yüksek bilişsel seviye soru tiplerini kullanım sıklığını arttırdığını ortaya koymuştur (ör., Erdogan & Campbell, 2008; Martin & Hand, 2009). Öte yandan bazı çalışmalar, etkili soru stratejisi için yüksek seviyede soru tipinin düşük seviyede sorulara göre daha sık kullanılması gerekmediğini savunmaktadır (ör., Goodwin, Sharp, Cloutier, & Diamon, 1983; Konya, 1972). Örneğin, Konya (1972) öğretmenin yüksek ve düşük seviyede soruları benzer oranlarda (yüzde 50) kullandığı sınıf uygulamalarının, öğrencinin yüksek seviye cevap vermesini tetikleyen en etkili yöntem olduğunu gözlemlemiştir. Yüksek bilişsel seviyede sorular genellikle öğrencide yüksek bilişsel seviyede cevabı tetikleyen en etkili soru tipi olarak savunulurken, öğretmenin soru tiplerini hangi sıklıkla kullanması gerektiğine dair çelişkili bir durum ortaya çıkmaktadır.

Öğretmen soru tiplerinin etkisini öğrenci cevaplarını gözeterek inceleyen bazı çalışmalar, öğretmen yüksek seviyede soru sorsa dahi cevapların %50'sinden fazlasının düşük bilişsel seviyede olduğunu gözlemlemiştir. Dillon (1982) bu durumu 'Yüksek seviyede soru sor, herhangi bir seviyede cevap al' sözleriyle özetlemiştir (s. 549). Yüksek seviyede öğretmen soruları ve yüksek seviye öğrenci cevapları arasındaki ilişkiyi inceleyen araştırmalar çelişkili sonuçlar bulmuştur (Redfield & Rousseau, 1981; Winne, 1979). Bazı araştırmalar doğrudan bir ilişki tespit ederken diğerleri yüksek seviyede soru tipinin yüksek düzeyde cevabı garantilemediğini ortaya koymuştur. Gall (1970) literatürdeki bu çelişki durumun sebebini soru tiplerini sınıflandırmak için başvurulan taksonomilerin yetersizliği ile alakalı olabileceğini savunmuştur. Çoğu soru sınıflandırma taksonomileri öğretmenlerin başvurması gereken soru tiplerindense, sınıflarda kullandıkları soru tiplerinin çeşitliliğini gözeterek oluşturulmuştur (Gall, 1970). Ayrıca, öğretmen sorularının etkililiği soruları birbirinden bağımsız olarak ele almak yerine soru tiplerinin bütüncül olarak değerlendirilmesini gerektirir. Gall (1970) bu bağlamda, öğretmen soru tiplerinin öğrencilerin bilişsel becerileri üzerine etkisinin aynı zamanda soru tiplerinin hangi sıralamada kullanıldığı da gözetilerek ele alınması gerekliliğini savunmuştur.

Soru sorma yöntemlerinin geliştirilmesi amacıyla mesleki gelişim programları bağlamında bazı çalışmalar yürütülmüş ve öğretmen soru sorma yöntemleri program öncesi ve sonrasında incelenmiştir. Eğitim literatüründe, mesleki gelişim programlarının gerekliliği birçok araştırmacı tarafından vurgulanmasına rağmen (ör., Dantonio, 1990; Fairbain, 1987; Joyce & Showers, 1983; Otto & Schuck, 1983; Savage, 1998), öğretmen soru sorma yöntemlerini mesleki gelişim programları aracılığıyla inceleyen sınırlı sayıda araştırma bulunmaktadır (Bolen, 2009).

Soru sorma stratejilerinin geliştirilmesini hedefleyen mesleki gelişim programlarının içeriği çeşitlilik göstermektedir. Birçok araştırmacı (ör., Windschitl, 2002; Czerniak & Lumpe, 1996) mesleki gelişim programlarının öğretmenlerin öğrenme ve öğretmeye dair bilgi, inanç ve algılarını hedeflemesi gerekliliğini savunmaktadır. Bu araştırmacılar, mesleki gelişim programının amacı yalnızca öğretmen soru yöntemlerini geliştirmek olsa dahi, öğretmenin öğrenmeye dair var olan algı ve inançlarını değiştirmeden etkili bir gelişim beklenemeyeceğini savunmaktadır. Ayrıca, çoğu öğretmen gelişim programı kısa dönemli seanslar halinde gerçekleştirilmektedir. Öğretmen gelişimini uzun vadeli olarak inceleyen sınırlı sayıda araştırma vardır (Benus, Yarker, Hand, & Norton-Meier, 2013). Bu noktada, eğitim literatüründe, öğretmen gelişimini uzun vadede, öğretmenlerin öğrenme ve öğretmeye dair algı ve inanç değişimlerini gözeterek inceleyen mesleki gelişim programlarının gerekliliği göze çarpmaktadır.

Bu çalışma ATBÖ çerçevesinde yürütülen boylamsal bir mesleki gelişim programı bağlamında gerçekleştirilmiştir. Çalışmanın amacı, ATBÖ yaklaşımının uygulandığı sınıflarda öğretmen sorularının farklı uygulama seviyelerine göre tanımlanmasıdır. Öncelikli olarak yüksek seviyedeki ATBÖ uygulamalarında sorulan öğretmen soruları tanımlanmış ve yüksek uygulama seviyesinde sorulan sorular ile orta seviye sınıf uygulamalarında sorulan sorular arasındaki farklılıklar incelenmiştir. Sonrasında ise öğretmenlerin soru tiplerini hangi sıralama ile kullandıkları ele alınmıştır. Çalışmayı yönlendiren araştırma soruları aşağıdaki gibidir:

1. Orta ve yüksek seviye ATBÖ uygulamalarında sorulan öğretmen soru tipleri arasındaki farklılıklar nelerdir?

2. Orta ve yüksek seviye ATBÖ uygulamalarında kullanılan öğretmen soru örüntülerinin temel özellikleri nedir?

Ulusal ve uluslararası bağlamdaki fen eğitimi reformları başarılı bireyler yetiştirmek için ATBÖ'ye dayalı öğrenme ortamlarının kurgulanmasını önerdiğinden bu sınıf uygulamalarını yakından incelemek önem arz etmektedir. Bu çalışma, yüksek kaliteli ATBÖ sınıflarında sorulan öğretmen soru yöntemlerini orta seviye ATBÖ uygulamalarında sorulan sorularla kıyaslayarak öğretmen ve araştırmacılara zengin bilgiler sunmaktadır. Öğretmen sorularının farklı seviyelerdeki ATBÖ uygulamalarına göre incelenmesinin temel dayanağı öğretmen soru sorma yöntemi ve uygulama seviyesi arasında doğrudan ilişki oluğunu ortaya koyan çalışmalardır (ör., Martin & Hand, 2009; Omar, 2004; Pimentel, 2010; Promyod, 2013). Yüksek seviye ATBÖ sınıflarında sorulan sorular yüksek seviye soru stratejiesi hakkında bilgi verirken, bu soruların orta seviye sınıf uygulamalarında kullanılan soru tipleri ile kıyaslanması öğretmenlerin soru sorma yöntemlerini geliştirirken yaptıkları hamleler hakkında bilgiler sunmaktadır.

Her bir araştırma sorusunu cevaplamak için çoklu durum çalışma desenine başvurulmuştur. Durum çalışması "bir örneğin, olgunun veya sosyal birimin, yoğun, bütüncül bir biçimde tanımlanması ve analizi" olarak ifade edilirken (Merriam, 1988, s.21 akt. Merriam, 1998, s.27), durum çalışmasının bir çeşidi olan çoklu durum çalışması birden fazla durumun genel bir amaç için incelenmesi olarak tanımlanmaktadır (Stake, 1995).

Çalışmada yer alan katılımcılar 2 fen bilimleri öğretmenidir. Katılımcılar, Türkiye'de ATBÖ bağlamında yürütülen boylamsal bir mesleki gelişim programına katılan öğretmenler arasından seçilmiştir. Mesleki gelişim programına katılan öğretmenler arasından çalışmanın örneklemini seçmek için amaçsal örnekleme metodu kullanılmıştır. Amaçsal örnekleme, araştırmacıların katılımcılara dair belirli ölçütleri kullanarak seçim yaptığı durumlarda kullanılabilir (Fraenkel & Wallen, 2006). Bu çalışmada örneklem seçimi aşamasında göz önünde bulundurulan kriter, öğretmenlerin ATBÖ'ye dayalı uygulama seviyeleridir. Katılımcılar seçilirken her birinin orta ve yüksek seviye ATBÖ uygulama videosunun ulaşılabilirliği dikkate alınmıştır. Öğretmenlerin düşük seviye sınıf uygulamalarından kısıtlı video kaydına ulaşılabildiği için bu çalışma, yalnızca orta ve yüksek uygulama düzeylerinde öğretmen video kayıtlarını içermektedir. Düşük seviyede uygulama videosuna ulaşılamama durumu çalışmanın sınırlılıklarında belirtilmiştir.

Çalışmaya ait veriler, öğretmenlerin kendi sınıflarında yaptıkları ATBÖ uygulamalarından alınan video kayıtlarından oluşmaktadır. Her bir öğretmenin orta ve yüksek seviyede ATBÖ uygulamalarını içeren video kayıtları çalışmanın verilerini oluşturmaktadır. Uygulama videoları aracılığıyla toplanan veriler çok durumlu karşılaştırmalı (multiple cross-case) yöntem ile analiz edilmiştir. Çalışmanın analizi öncelikle, her bir öğretmen için birbirinden bağımsız olarak gerçekleştirilmiş ve sonrasında karşılaştırılmalı yöntem ile öğretmenlerin soru sorma yöntemlerine ilişkin benzerlik ve farklılıklar tartışılmıştır. Çok durumlu karşılaştırmalı analiz durumlardan elde edilen sonuçların uyuşan ve uyuşmayan yönlerini belirlemek için kullanılabilir (Merriam, 1998). Durumlar arasında ortaya çıkan farklılıklar durumların karakteristik özellikleri ile eşleştirilirken, benzer özellikler araştırılmak istenen konuya yönelik kanıtları güçlendirmektedir (Harootunian, 2007).

Daha önce bahsedildiği üzere katılımcılar, Türkiye Bilimsel ve Teknolojik Araştırma Kurumu (TÜBİTAK) tarafından desteklenen bir mesleki gelişim projesine katılan öğretmenler arasından seçilmiştir. Proje, Türkiye genelinden 30 fen bilimleri öğretmeninin ATBÖ uygulamalarına yönelik bilgi, beceri ve yeterlilik geliştirmesini hedeflemiştir. Üç yıllık (6 akademik dönem) proje kapsamında öğretmenler her dönem hizmetiçi eğitime katılmış ve devam eden eğitim-öğretim döneminde kendi sınıflarında ATBÖ uygulamaları yürütmüşlerdir. Her dönem yürütülen uygulamaların video kayıtları alınmış ve Reform Tabanlı Eğitim Gözlem Protokolü (RTOP) kullanılarak uygulama düzeyleri tespit edilmiştir. Mesleki gelişim programına katılan 30 öğretmen arasından uygulama düzeyleri gözetilerek seçilen 2 öğretmenin orta düzey ATBÖ uygulamaları programın 3. dönemine denk gelirken, yüksek düzey uygulamala videoları programın 4. döneme tekabül etmektedir.

Her öğretmenden alınan orta ve yüksek düzey ATBÖ uygulama videoları araştırmacı tarafından transkript edilerek her bir uygulamada sorulan öğretmen soruları ve karşılığında verilen öğrenci cevapları tespit edilmiştir. Öğretmen soru tipleri, Graesser ve Person (1994) tarafından geliştirilen Soru Tipi Taksonomisi (Taxonomy of Question Types) aracıyla belirlenirken, öğrenci cevaplarının bilişsel düzeyleri Grimberg ve Hand (2009) tarafından geliştirilen bilişsel becerileri kodlama ölçeği ile belirlenmiştir.

Graesser ve Person (1994) tarafından geliştirilen soru tipi taksonomisi 3 tip soru kategorisini içermektedir. Bunlar; kapalı uçlu, açık uçlu ve yönetim sorularıdır. Kapalı uçlu sorular genellikle bilgi veya ezber tabanlı cevap gerektiren sorular olarak tanımlanırken, açık uçlu sorular öğrenciyi bilgiyi yorumlama, analiz ve sentez yapmaya yönelten sorulardır. Yönetim soruları ise öğrenciler deney yaparken ya da sınıf içerisinde bir yönergeyi uygularken öğrencileri yönlendirme amaçlı kullanılan soru tipidir (Graesser & Person, 1994). Hmelo-Silver (2003), Graesser ve Person tarafından geliştirilen soru tipi taksonomisini revize etmiş ve gözlemlemiş olduğu üstbilişsel soru tiplerini 'üstbilişsel-yönetim soruları' başlığı altında eklemiştir. Taksonomi, Hmelo-Silver tarafından revize edilmiş haliyle 3 temel soru tipini içermektedir: 1) kapalı uçlu sorular, 2) açık uçlu sorular ve 3) üstbilişsel-yönetim soruları.

Hemolo-Silver, çalışmasında üstbilişsel ve yönetim sorularını bir başlıkta ele almasına rağmen bu çalışmada bu kategori, üstbilişsel sorular ve yönetim soruları diye 2 ana kategoriye ayrılmıştır. Bu ayrımın yapılmasındaki temel etken bu çalışmada üstbilişsel ve yönetim sorularının farklı amaçlara hizmet ettiğinin gözlemlenmiş olmasıdır. Sonuç olarak bu çalışmada öğretmen soru tipleri 4 ana kategori baz alınarak kodlanmıştır: 1) kapalı uçlu sorular, 2) açık uçlu sorular, 3) yönetim soruları ve 4) üstbilişsel sorular.

Öğrenci cevaplarının bilişsel düzeylerini belirlemek üzere Grimberg ve Hand'in (2009) geliştirdiği, 3 temel düzeyden oluşan bilişsel beceriler değerlendirme ölçeği kullanılmıştır. Düşük, orta ve yüksek seviye bilişsel beceriler sırasıyla algı, kavrama ve soyutlama basamakları ile ilişkilendirilmektedir. Algı basamağı gözlem yapma, ölçüm yapma, ve karşılaştırma gibi temel becerileri içerirken, kavrama basamağı örnekseme, iddia, açıklama ve sebep/sonuç ilişkilerine dair akıl yürütmeyi gerektirmektedir. Yüksek düzey bilişsel beceriler olarak adlandırılan soyutlama basamağı argüman kurma, tümdengelim, tümevarım ve araştırma tasarlama gibi becerileri içermektedir.

Öğretmen soru tipi ve öğrenci cevaplarının bilişsel düzeyleri kodlandıktan sonra bağımsız bir araştırmacı kodlamaları revize etmiştir. Kodlar arasında var olan uyuşmazlıklar tespit edilerek, araştırmacıların biraraya gelerek kodlar üzerinde fikir birliği yapmaları sağlanmıştır.

Video kayıtlarının transkript edilmesiyle elde edilen yazılı dokümanlar, söylem çözümlemesi kullanılarak analiz edilmiştir. Birinci araştırma sorusu kapsamında söylem analizi, Chi-square analiz yöntemi ile birleştirilmiştir. Öğretmenin her bir soru tipini ne sıklıkta kullandığını belirten toplam sayılar belirlenmiş ve orta ve yüksek seviyede kullanılan soru tipleri sıklıkları arasında istatistiksel olarak anlamlı bir farklılık olup olmadığı tespit edilmiştir. Chi-square analizi bu istatistiksel anlamlılığın tespiti sırasında kullanılmıştır.

Daha önce bahsedildiği üzere araştırma soruları her bir öğretmen için birbirinden bağımsız bir şekilde cevaplanmıştır. Sonrasında karşılaştırmalı durum analizi ile orta ve yüksek seviyedeki soru yöntemleri arasındaki farklılıkların öğretmenler arasında uyuşup uyuşmadığı tespit edilmiştir. Karşılaştırmalı durum analizi, öğretmenlerin orta ve yüksek seviyede sergiledikleri soru yöntemleri arasındaki farklılıkların her iki öğretmende de tutarlı olduğunu orta koymuştur.

Öğretmenler yüksek seviye ATBÖ uygulamalarında kapalı uçlu soru tipini en fazla kullanırken, en az sıklıkla başvurulan soru tipi yönetim soruları olmuştur. Üstbilişsel soru sorma oranı kapalı uçlu soru sayısıyla benzer iken, açık uçlu sorular, kapalı ve üstbilişsel soru tiplerine kıyasla nadiren tercih edilmiştir.

Öğretmenlerin orta ve yüksek seviye sınıf uygulamalarında kullandıkları soru tipleri kıyaslandığında, uygulama düzeyleri arasında farklılık yaratan soru tiplerinin üstbilişsel ve kapalı uçlu sorular olduğu gözlemlenmiştir. Yüksek uygulama seviyesinde öğretmenlerin üstbilişsel soru sorma oranı artarken, kapalı uçlu soru sayıları azalma göstermiştir. Chi-square analiz sonuçları öğretmelerin farklı uygulama düzeylerinde, kapalı uçlu ve üstbilişsel soru sayıları arasındaki bu farklılığın istatistiksel olarak anlamlı olduğunu ortaya koymuştur. Uygulama düzeylerine bağlı olarak açık uçlu ve yönetim soru sayıları arasında önemli bir farklılık gözlemlenmemiştir.

Araştırma soruları kapsamında olmamasına rağmen, öğretmenlerin orta ve yüksek uygulama düzeyinde sordukları toplam soru sayıları karşılaştırılmıştır. Orta düzeyde sorulan toplam soru sayısının yüksek uygulama düzeyinde sorulan sorudan fazla olduğu ancak bu fazlalığın istatistiksel olarak anlamlı bir farklılık göstermediği ortaya koyulmuştur. Öğretmenin uygulama düzeyi arttıkça sorduğu soru sayısındaki azalmayı, benzer bir şekilde Martin ve Hand (2009) yaptıkları çalışmada gözlemişlerdir. Araştırmacılar, iyi sınıf uygulamasında öğretmen soru sayısındaki azalmayı öğrencilerin süreçte daha aktif rol almalarıyla açıklamışlardır. Yüksek uygulama seviyelerinde öğretmen soru sayısındaki azalma dersin odağının öğrenciler tarafından belirlendiği esnek bir sınıf ortamına işaret etmektedir. Diğer taraftan Erdogan ve Campbell (2008) yüksek uygulama seviyelerinde öğretmen soru sayısının arttığını gözlemlemiş ve bu durumu öğretmenin öğrenci-merkezli öğrenme ortamlarındaki aktif rolüyle ilişkilendirmişlerdir. Öğretmen uygulama seviyesi geliştikçe sınıf ortamında sorduğu toplam soru sayısının ne yönde değişmesi gerektiği hakkında literatürde çelişkili sonuçlar göze çarpmaktadır. Örneğin, bir diğer araştırmacı Gadamer (1993), öğretmen soru sayısının artması veya azalması gerekiliğinin önem arz etmediğini ancak temelde önemli olan konunun öğretmenin yüksek seviye soru tipini kullanması olduğunu vurgulamıştır. Yüksek bilişsel seviyedeki bir soru, düşük bilişsel seviyede sorulan yüz sorudan daha etkili olabileceğinden toplam soru sayılarını kıyaslamak önemli bir anlam ifade etmemektedir (Gadamer, 1983).

Bu çalışma kapsamında öğretmenin kullandığı çoklu soruların (multiple string questions) yapı ve içeriği de incelenmiştir. Çoklu sorular, Fink (1987) tarafından herhangi bir cevapla kesilmeden, ardarda sorulan sorular dizisi olarak tanımlanmıştır. Öğretmenlerin orta ve yüksek uygulama seviyelerinde benzer sıklıkla çoklu soru kullandığı gözlemlenmiştir. Çoklu soruların uzunluğu, bir diğer ifadeyle ardarda sorulan soru sayıları arasında uygulama düzeyine göre önemli bir fark gözlemlenmemiştir. Çoklu sorular birbirini tekrar eden sorulara yol açarken öğretmenin sorular arasında bekleme süresini gözetmediğiyle de ilişkilendirilir (White & Lightbrown, 1984). Öğretmenin çoklu soru kullanımı bu sebeple geleneksel öğrenme ortamlarıyla ilişkilendirilirken bu çalışmada öğretmenin çoklu soruları genellikle bir önceki soruda sorulan duruma açıklık getirmek veya başlangıç sorusuna verilecek cevapların sınırlarını daraltmak amacıyla kullandığı gözlemlenmiştir.

Öğretmen soru tipi ve öğrenci cevaplarının bilişsel düzeyi arasındaki ilişki incelenerek, ilk defa bu çalışmada, üstbilişsel sorular öğrencinin yüksek bilişsel seviyede cevap vermesinde rol oynayan en etkili soru tipi olarak tanımlanmıştır. Öğretmen soru sorma yöntemleri üzerine literatür, üst seviye soru tipini genellikle açık uçlu sorular ile ilişkilendirmektedir (Graesser & Person, 1994). Ancak bu çalışmada açık uçlu sorular öğrencilerin argüman kurma, tümevarım ve tümdengelim yapma gibi üst düzey bilişsel becerileri tecrübe etmelerinde etkili olamamıştır. Bu becerilerin teşvik edilmesinde rol oynayan en etkili soru tipinin üstbilişsel sorular olduğu gözlemlenmiştir. Orta düzey ATBÖ uygulamalarında yüksek seviye öğrenci cevaplarının ortalama %50'si üstbilişsel sorular tarafından tetiklenirken yüksek uygulama seviyelerinde bu oran %63'ü bulmaktadır.

Öğretmen soru tipi, öğrencide yüksek bilişsel seviyede cevabı tetikleyen önemli bir faktördür (Chin, 2007; Gall, 1970; Pate & Bremer, 1967), ancak soru tipleri birbirinden bağımsız bir şekilde incelenmemelidir (Gall, 1970; Taba, 1966). Bu bağlamda, bu çalışma orta ve yüksek seviye ATBÖ uygulamalarında yüksek bilişsel seviyede cevabı tetikleyen soru desenlerini incelemiştir. Soru deseni bu çalışmada öğretmenlerin soru tiplerini hangi sıralama ile kullandıklarına dair incelemeleri içermektedir. Öğretmenlerin hem orta seviye hem de yüksek seviye ATBÖ uygulamalarında belirli bir sıralama gözettiği belirlenmiştir. Dersin başlarında çoğunlukla kapalı uçlu ve açık uçlu sorular sormayı tercih ederken, dersin ortalarında üstbilişsel soru sıklığını da arttırarak her üç soru tipine de başvurmuşlardır. Dersin sonlarına doğru sıklıkla kullanılan soru tipi üstbilişsel sorular olmuştur. Yönetim sorularının belirli bir düzen ile sorulmadığı gözlemlenmiştir. Kapalı ve açık uçlu sorular öğrencide kavramsal ya da bilgi tabanlı çelişki oluşturmak için kullanılırken, üstbilişsel sorular öğrencide üst düzey bilişsel becerileri tetiklemek için sorulmuştur. Öğretmenler, üstbilişsel soruları sormadan önce diğer soru tiplerini kullanarak kavramsal çelişki yaratmış ve bu çelişkiyi üstbilişsel sorularla tetikleyerek öğrencileri argüman kurma, tümdengelim ve tümevarım gibi becerileri tecrübe etmeye yönlendirmiştir. Üstbilişsel sorular öğrencide yüksek seviyede bilişsel becerileri tetikleyen en etkili soru tipi olmasına rağmen, yalnızca üstbilişsel soru kullanımının etkili bir soru sorma yöntemi olmadığı gözlemlenmiştir. Dersin başlarında sorulan üstbilişsel kategorideki soruların öğrencide üst düzey bilişsel becerileri tetiklemek için yetersiz olduğu görülmüştür. Öğretmenler, bu kategorideki soru tipinden etkili cevaplar alabilmek için öncelikle kapalı ve açık uçlu sorularla kavramsal çelişki oluşturmuşlardır.

Öğretmen soru tipi sıralamasına yönelik bu sonuçlar Taba'nın (1966) çalışma sonuçlarıyla benzerlik göstermektedir. Taba da benzer şekilde etkili soru sorma yöntemi için öğretmenlerin önce düşük seviye soru tiplerini kullanmaları sonrasında üst düzey soru tiplerine başvurmaları gerektiğini savunmuştur. Öğretmenlerin soru tiplerini hangi sıralamada kullandığının, etkili soru sorma yöntemine dair ipuçları vereceği, dolayısıyla bu durumun öğrenci bilişsel beceri düzeyleri üzerindeki etkisinin incelenmesi gerektiği Gall (1970) tarafından önerilmiş olmasına rağmen, yakın zamanda bu alanda yapılmış çalışmaya rastlanmamaktadır.

Bu çalışma, 587 öğretmen sorusu ve öğretmen soruları ile öğrenci cevap seviyeleri arasındaki ilişkiyi orta ve yüksek seviyede ATBÖ sınıflarında inceleyerek öğretmenlere ve araştırmacılara kaliteli soru sorma yöntemi hakkında zengin bilgiler sunmaktadır. Bu çalışmada öğrenci bilişsel becerilerini tetiklemede en etkili soru tipi olarak beliren üstbilişsel soru tiplerinin etkililiğinin, ilerleyen çalışmalarda da test edilmesi ve bu soru tipinin öğrenci cevaplarına olan etkisine yönelik daha fazla kanıt sunulması tavsiye edilmektedir. Aynı zamanda diğer durum çalışmalarında olduğu gibi çalışmanın bulguları öğretmenlerin veya sınıfların kendine özgü özellikleri ile sınırlı olabilir. Farklı öğretmenlerle yapılan bir çalışma farklı sonuçlara yol açabilir. Bu nedenle gelecek çalışmalar farklı sınıf düzeyleri ve üniteler kullanılarak tekrarlanmalıdır.

APPENDIX C

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☐

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : Kılıç
Adı : Burcu
Bölümü : İlköğretim Fen ve Matematik Alanları Eğitimi

TEZİN ADI (İngilizce) : INVESTIGATING QUESTIONING PATTERNS OF TEACHERS THROUGH THEIR PEDAGOGICAL PROGRESSION IN ARGUMENT-BASED INQUIRY CLASSROOMS

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ☐

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. ☐

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: