Fall 2014

Examining two Turkish teachers' questioning patterns in secondary school science classrooms

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EXAMINING TWO TURKISH TEACHERS' QUESTIONING PATTERNS IN SECONDARY SCHOOL SCIENCE CLASSROOMS

by

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A thesis submitted in partial fulfillment
of the requirements for the Master of
Science degree in Teaching and Learning (Science Education)
in the Graduate College of
The University of Iowa

December 2014

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CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's thesis of

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for the thesis requirement for the Master of Science
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To all teachers who cherish humanity…
…and have devoted themselves to the betterment of mankind.

… Don’t be satisfied with stories,
How things have gone with others.
Unfold your own myth,
Without complicated explanation…

Rumi

ABSTRACT

This study examined low and high level teachers', determined according to their students' writing scores, questioning patterns and classroom implementations within an argument-based inquiry approach known as the Science Writing Heuristic (SWH) approach, which addresses issues on negotiation, argumentation, learning, and teaching. The level of the teachers was determined by the students' writing scores. This study was conducted in Turkey with six teachers for preliminary study. Because scoring writing samples examines the students' negotiation level with the different sources and students learn scientific process, as negotiation, which they may transfer into their writing, in classroom, two teachers were selected to represent low and high level teachers. Data collection involved classroom observation through video recordings. The comparative qualitative method was employed throughout the data analysis process with including quantitative results. The research questions that guided the present study were: (1) How are low and high level teachers, determined according to their students' writing scores, questioning patterns different from each other during classroom discourse? (2) Is there a relationship between students' writings and teachers' questioning styles in the classroom? Analysis of Qualitative data showed that teachers' classroom implementations reveal big differences based on argumentation patterns. The high level teacher, whose students had high scores in writing samples, asked more questions and the cognitive levels of questions were higher than the low level teacher. Questions promote an argumentative environment and improve critical thinking skills by discussing different ideas and claims. Asking more questions of teacher influences students to initiate (ask questions) more and to learn the scientific process with science concepts. Implicitly, this learning may improve students' comparison in their writing. Moreover, high level teacher had a more structured lessons and organized classroom implementation than low level teacher.

PUBLIC ABSTRACT

This study examines teachers' implementation of argument-based inquiry in their science classroom. Argument-based inquiry approach is a kind of active learning where the students behave like real scientist. Argument-based inquiry approach means that students start with a question which they want to ask about the topic, then do their experiment to answer their question. Findings are used as evidence to support their claims. Moreover they discuss and negotiate about their findings. In the preliminary study, students' writing samples were scored according to their compare and contrast quality between their findings and different sources. The scores of the writing samples are assumed as an indicator of their negotiation quality. While learning the context of science in the classroom, students learn the process of negotiation; thus, students' writings reflect their learning of negotiation. According to results of writing samples, the teachers are classified and two of them selected to represent low and high implementation of argumentation. In the main study, these two teachers' classroom talking and questioning patterns are compared. The analysis of qualitative data shows that (1) high level teacher asked more question, (2) asking more questions of teacher influenced their students to ask more question and learn scientific process, and (3) high level teacher had a more structured and organized classroom than low level teacher. These results can help science teachers who are eager to implement argumentation in their classrooms. They need to be more organized, ask more questions to support their students to talk, and let their students to ask questions to each other.

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CHAPTER I

INTRODUCTION

Inquiry and Science Teaching

In science classrooms, in the light of the constructivist perspective, inquiry has become more popular and a great emphasis in science teaching and learning in the second half of the twentieth century to today (Abd-El-Khalik, BouJaoude, Duschl, Lederman, Mamlok-Naaman, Hofstein, Niaz, Treagust, & Tuan, 2004). In national science education reform documents (NRC, 1996) the National Research Council has pushed for much more emphasis on scientific inquiry and for the need for students to be involved in inquiry activities which promote critical thinking. According to the National Science Education Standards (NRC, 2000), the essential features of inquiry are stated from the perspective of learners. Learners need to engage with scientific questions, find evidence to explain and answer the question, be able to compare his/her explanations with alternatives, and communicate and justify their explanations.

Inquiry is not only a method to teach science, but also a process which needs to be learned by students as an outcome of science teaching. Learners do hands-on and minds-on activities during inquiry process, and after learning happens, learners should be able to apply scientific inquiry to new situations in their daily life (NRC, 1996, 2012). Despite the importance of inquiry, the implementation level of inquiry in science classrooms is not as intended by the standards. To improve implementation level of inquiry, teachers should learn how an inquiry process occurs. Inquiry should start with curiosity and a question about phenomena; the curiosity and questioning phase may start with some awareness of phenomena, and may continue with an experiment, research, observation, design or so on. Moreover, based on previous activities, learners have some evidence, results, or assumptions to answer the initial questions and then give an explanation in keeping with his/her findings. The learner needs to make a comparison between the answers of his/her peers and science literature, and also be able to justify their findings and answers (NRC, 2000). After this process, the learner learns both scientific concepts and the scientific process, and as a member of scientific-literate society, uses it in new conditions in daily life.

A framework for K-12 Science Education, “Practices for K-12 Science Classrooms” (NRC, 2012) has provided a new perspective which stresses that engaging in scientific inquiry requires coordination both of knowledge and skills simultaneously. In the last few decades, researchers have emphasized two key features about participating in scientific inquiry practices: (1) students should use data and scientific concepts that they are studying to constructs models or explanations, and (2) students should argue their scientific ideas (Berland and Reiser, 2009). Argumentation, which is a significant part of scientific inquiry, is often disregarded inside the classroom (Sampson, Grooms, & Walker, 2011). From *Essential Features of Inquiry* (NRC, 2000) to the *Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012, there is increasing emphasis on argumentation, modeling and explanation. These changes aim to help teachers by making more visible the requirements and definition of inquiry. By defining “Practices” (NRC, 2012) more clearly, the standards aim to open more space for the scientific inquiry in classrooms. Improving the implementation level of inquiry in science classrooms is necessary to increase learning science for scientifically literate society because inquiry learning is an active learning.

Inquiry learning is a kind of active learning and it is assessed by how well students develop analytical and experimental skills rather than how much knowledge they possess. The concept of using inquiry has had a significant role in science teaching and learning since the 1960s through to today. For example, according to the U.S. National Science Education Standards (NRC, 1996), inquiry is important in order to advance science literacy. The aim, through inquiry, is to have a literate society in which members are able to think critically by using the process of scientific argumentation. To become a critical thinker by engaging in challenging cognitive activities in science is not easy without structured support. A structured support is necessary for students to use strategies of appropriate reasoning. Inquiry teaching aims “to create a bridge between observation and the ideas of science.”(Wellington and Osborne, 2001). To construct this bridge, students need to be able to use the ideas and language of science (Hand, 2008). At this point, each individual constructs knowledge by using his/her own scientific language in his or her learning environment.

Argumentation in Science Classrooms

In a negotiation process, students use what they know about science concepts and scientific language (Norris & Phillips, 2003). From this perspective, language and argumentation are important to construct the scientific knowledge while learning and teaching as inquiry (Wallace & Narayan, 2002). Moreover, argumentation is a characteristic of science communities (Hand, 2008). In a scientific discipline, scientists start with prior knowledge and plausible reasoning. To attain new results and knowledge, they need to find some data and evidence, and make an argument using this data in a scientific context. Based on this argumentation, they develop a scientific explanation that is consistent with evidence and facilitates accurate predictions. A scientific argument needs to be logical, related to the evidence, open to criticism, have methods and procedures. Science-literate people have advanced abilities in scientific argumentation and reasoning which involves claims, evidences, rebuttal, and counterclaims. For the better understanding of the nature of science and scientific knowledge, effective argumentation is needed (Hand, 2008).

These are the main characteristics of scientific communities which are needed in a science classroom environment. In an argument based inquiry classroom, students decide what their beginning point is by posing questions about the subject. Afterwards, they need to make some claims to answer their questions and support their claims with evidence. Students need to use the data to construct their own unique knowledge in their mind. Argumentation, where the learner become more active, helps learners to construct their own knowledge. Moreover, “argument can be both an individual activity done through thinking and writing, or it can be a negotiated social act.”(Hand, 2008, p. 21). Through argumentation, students experience a scientific learning process in the classroom. In this manner, students have opportunities to engage with science and become members of science-literate society.

Scientific literate people can reach for the scientific knowledge, use it in familiar or unfamiliar contexts, and discuss scientific issues with other people. Moreover, in the light of constructivism, inquiry and argumentation, “knowledge is constructed in the social context of the classroom through language and other semiotic means” (Chin, 2006, p.1316) by the learners. For scientific literate society, students should learn this method of scientific communities in the classroom. Scientific discourse in science classrooms ought to support interaction between teachers and learners, and learners to learners. There are different types of classroom discourse patterns and these are defined differently by different researchers: dialogue vs. monologue, authoritative vs. dialogic, or interactive vs. non-interactive (Scott, Mortimer, & Aguiar, 2006).

Discourse in Science Classrooms

The discourse strategies in the science classroom can be a dialogue or monologue (Scott et al., 2006). Monologue strategies include mostly teacher talking and its direction is from teacher to students, the focus generally on knowledge transfer. The teacher conveys information and teacher instruction always includes instructional questions, factual statements, and reviews. It is used for backgrounding, foregrounding, narrative, and selective summary (Chin, 2007). The dialogue strategy, which is desired in inquiry and argumentation classrooms, includes students' voices rather than teacher's voice. Dialogic discourse encourages students to challenge and debate, and is based on open or genuine questions. Moreover, it allows students to argue and justify their ideas (Chin, 2007). Classroom discourse can include one or both. For instance, the teacher can start with a monologue strategy by giving background information and question, and then he/she directs the students to have a dialogic interaction. Dialogic discourse helps students to construct their own knowledge. Classroom interaction is generally dialogue or monologue questioning and questioning styles assist in creating a meaningful learning and scientific environment (Scott et al., 2006). To have an understanding about questioning in science classroom will provide an understanding how the meaningful learning occurs throughout the classroom discourse.

Questioning in Science Classrooms

Questioning is common in science classroom environments and has an important role in revealing students' prior knowledge, and in helping to create and support their claims. Questions promote an argumentation environment and improve critical thinking skills by discussing different ideas and claims. During questioning, students realize misconceptions and negotiate different ideas, and then choose to support or reject those ideas (Gunel, Kingir, & Geban, 2012, Chin&Osborne, 2008). Because the questioning can provide an argumentative environment for learners, questioning is a significant factor in argumentation. Different types of questions can trigger different types of thinking ability. According to Bloom's taxonomy (1956), while some questions require answers which require only remembering knowledge, some questions require high level thinking skills like application, analysis or evaluation (Bloom, 1956). During classroom discourse and argumentation, if questions are aimed at high level thinking abilities, and each answer is followed by high level questions, student will be motivated to negotiate at a high level.

The student's style of questioning is strongly related to the teacher's attitude. If the teacher asks questions to get answers at the knowledge stage, the number of students' questions decreases and vice versa (Gunel, et al, 2012, van Zee, Iwaysk, Kurose, Simpson & Wild, 2001). A teacher has a vital role in students' questioning because when a teacher leaves students on their own, students are not willing to ask more questions of each other(Aguiar, Mortimer, & Scott, 2010; Chin & Osborne, 2008). There are some findings which show that there are more student questions in argument-based inquiry teaching environments and moreover, students are tend to ask more questions during their group studies (van Zee, et al, 2001). To help students to ask more questions and interact with each other, the teacher needs to create an argument based inquiry environment in the classroom and needs to trigger questioning in the classroom (Gunel, et al, 2012). For this, teachers can use approaches which include inquiry and argumentation for science classrooms. One of these approaches is the Science Writing Heuristic (SWH), which combines inquiry, argumentation, language, writing and science. This approach will be introduced in the next chapter. Up to now, global view about inquiry, argumentation and questioning are represented. For this study, the data were collected from Turkey; therefore, the situation in Turkey for science education need to be examined.

Science Education Reform Efforts in Turkey

Developed countries, like the USA, Germany and Australia, achieve educational reforms for science education based on constructivism and inquiry in the last century (Akpinar & Aydin, 2007, NRC, 1996). In 2004, Turkey had a big revolution in education, and changed the curriculum in line with constructivist theory; thus science teaching and curriculum have developed in a new form which includes inquiry (MoNE, 2004). Lower results in international assessments, like TIMSS and PISA, and feedback from research on previous science curricula led to changes to promote scientifically literate society (Kilic, 2002). The new developed science curriculum aims for students to understand the nature of science and basic science concepts, principles, theories and laws and be able to apply them to daily life in an appropriate way, utilize science process skills during problem-solving and decision making, and understand the interaction between science, technology, society and environment (MoNE, 2004). Despite the change in the curriculum, Turkey has not reached intended goals in classroom implementation (Es & Sarikaya, 2010; Celen, Celik, & Seferoglu, 2011).

Ways of achieving the new curriculum goals are not understood and implemented by the teachers appropriately. The new inquiry-based curriculum aims for more student-centered learning rather than traditional teacher-centered teaching. Transforming the curriculum is easier than achieving transformation in a classroom environment which has multiple facets like the teacher, the students, assessments, and documents. Teachers are not familiar with the new curriculum and attend in-service training seminars but they do not do hands-on activities. These training initiatives are not enough to achieve transformation in the classroom. For instance, my observations of classroom implementation during my internship showed that the teacher had learned the classroom should be student-centered rather than lecturing because curriculum says so. But the teacher assigned parts of the unit to students, and students lectured to the classroom. The teacher only intervened to make clear some points, but while doing this, he is acting like the only source of knowledge. This is only one example of the misunderstanding of new approaches. If there is a change needed in the classroom, the most important role for this change belongs to the teacher. To overcome the lack of implementation of inquiry, the inquiry based learning approaches became a focal point by the researchers.

There are some endeavors, which include argument based inquiry that are getting more popular in science teaching in Turkey (Erduran, Ardac & Yakmaci-Guzel, 2006; Gumrah & Kabapinar, 2010; Kaya & Kilic, 2008), to implement the change in curriculum to practice in classroom. One of them is the Science Writing Heuristic (SWH) project which is named in Turkey “Argumentasyon Tabanli Bilim Ogrenme” (ATBO, Argument-based Science Learning) and which intends to change the teacher beliefs and implementation in the classroom.

Argument-based Science Learning Project in Turkey

The Argumentasyon Tabanli Bilim Ogrenme project is funded by The Scientific and Technological Research Council of Turkey (TUBITAK). It is a three year longitudinal professional development project. The main goals of the project were to expand teachers' content knowledge, to change their beliefs about teaching and learning, and support their pedagogical implementation strategies. Participant teachers use the SWH approach in their classrooms. The goal of the project is to change teachers' pedagogical implementation and epistemological beliefs to promote a classroom environment which is more student-centered and where scientific thinking is more common. For this aim, participant teachers need to learn how to combine the components of the approach, which are inquiry, argumentation, language, writing and science. Moreover, implementation were assessed according to students' academic achievements, critical thinking skills, and scientific beliefs.

There are some endeavors to improve classroom implementation of inquiry based learning and teaching in Turkey. Argument-based inquiry approaches getting more popular like the SWH approach. These endeavors and their results should be examined. The number of research in this field is increasing but these are not enough. In this study, the researcher will examine the teachers' argument-based inquiry implementations by focusing on their talk time, lesson organization, conversation patterns, and quality of questioning. The selection of the teachers are based on their students writing performances. Comparison of writing and classroom observation is not found frequently in the literature for science teaching in Turkey. This study can provide a new perspective for argument-based inquiry teaching research in the field by combining classroom implementation and quality of students' writing. For this aim, the researcher ask two research questions.

Research Questions

Students' writing samples were examined from participant teachers for the use of information from any source with related big ideas, a comparison between source and claim/evidences, and using different modes. Jang's (2011) scoring matrix was used to examine students SWH writing templates. The average scores of students' writings were varied from teacher to teacher. While one teacher had good scores, the other had low scores. This suggests some differences in the classroom implementation. To examine classroom implementation, teacher attitudes, student discourse, and teacher talk for the reasons, the researcher developed the following research questions:

1. How are low and high level teachers, determined according to their students' writing scores, questioning patterns different from each other during classroom discourse?
2. Is there a relationship between students' writings and teachers' questioning style in the classroom?

Chapter Overviews

Chapter 2 (Literature Review) addresses role of argumentation and questioning in learning science. It begins with explaining argumentation and its importance for science classrooms. Then, importance of language is explained as a learning tool to support argumentation. Types of argumentation patterns, socioscienctific, structural, and immersive approaches, are examined to show which approach is more appropriate in school science. The Science Writing Heuristic approach, which is the context of the study, is defined as an immersive and advisable approach for learning science. Further, it discusses the role of questioning and the effect of teacher questions in learning science.

Chapter 3 (Design and Methods) describes the qualitative methods used for this study. It provides detailed information about the context of the study and participants, and also the observation criteria and types. It discusses the origin of the study, the selection criteria of the participant teachers, an explanation of the analytical framework in detail, and inter-rater reliability reports. Moreover, the scoring matrix for the reading framework, Bloom's taxonomy, and the triadic dialog pattern are explained.

Chapter 4 (Results) breaks the analysis down into two phases. The first is a writing analysis and classification of six teachers. The second is video recording analysis of two teachers (one low and one high level) practicing the approach in the classroom. The analysis of the class time includes four different aspects: teacher talk time, quantity and quality of questioning, lesson organization (purpose of class), and conversation patterns. Writing samples are used to decide a teachers' level. The number of times a teacher talks (talk time) is examined to provide overall insight into the organization of the class period. A questioning pattern analysis investigates the quality of teachers' questions based on Bloom's taxonomy. A lesson Organization analysis looks at how the teacher organized classroom and students for argument based inquiry. Finally, a conversation pattern analysis focuses on each teachers dialog pattern using the framework of Lemke's (1990) triadic dialog pattern.

Chapter 5 (Discussion) will answer research questions posed in first chapter will be answered along with limitations of the study and implications. Specifically, the research question and results are reviewed by making connections between results and literature. The limitations of the study are addressed along with how they can be overcame. Finally, implications from the study to further research for researchers and to apply in class for teachers are presented.

CHAPTER II

LITERATURE REVIEW

This chapter addresses role of argumentation and questioning in learning science. It will begin with explaining argumentation and its importance for science classrooms. Then, importance of language will be explained as a learning tool to support argumentation. Types of argumentation patterns, socioscienctific, structural, and immersive approaches, will be examined to show which approach is more appropriate in school science. The Science Writing Heuristic approach, which is the context of the study, will be defined as an immersive and advisable approach for learning science. Further, it will discuss the role of questioning and the effect of teacher questions in learning science.

Argumentation in Science Learning

The main goal of the science education is, as defined in the *Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012) and the *Next Generation Science Standards* ([NGSS] NRC, 2013), to prepare students to become a member of scientifically literate society. To reach this goal, inquiry has been emphasized as central to science education (NRC, 1996; NRC, 2013) and has become more popular in research (Fang, 2005; Prain, 2009). Despite the lack of clear definition in the literature for what inquiry implies for science classrooms, Inquiry, practically, is an engagement process in which students actively advance their understanding of natural world with higher level thinking and develop reasoning skills as scientists do (Hand. 2008). The scientific inquiry interventions can be thought as replicating previous methods by using same instruments to verify scientific knowledge in textbooks, and there are numerous these kind of inadvisable examples that can be encountered in science classrooms. Essentially, scientific inquiry requires argumentative processes (Bricker & Bell, 2008; Zembal-Saul, 2009) in which students construct “knowledge claims through interpreting data as sound evidence and debating those claims with peers” (Chen, 2011, p. 10).

The shift from replicating scientific terminology to supporting the construction and communication of a comprehensive understanding of natural world through argumentation process is also emphasized in the NGSS (NRC, 2013) by placing argumentation at the center of scientific and engineering practices. Duschl and Osborne (2002) state that “teaching science as a process of enquiry without the opportunity to engage in argumentation, the construction of explanations and the evaluation of evidence is to fail to represent a core component of the nature of science or to establish a site for developing student understanding” (p. 41).

As Duschl and Osborne (2002) and NGSS (2013) pointed out, argumentation is a core practice and advisable for science learning and teaching because learner’s participation in argument improves “communication skills, metacognitive awareness, critical thinking, an understanding of the culture and practice of science, and scientific literacy” (Cavegnetto, 2010, p. 336). Adopting argumentation in science classroom interventions will involve an evolution from rote memorization to active participation in knowledge construction process (Duschl, Schweingruber, & Shouse, 2007; Berland & McNeill, 2010). By involving students with argumentation, knowledge construction process becomes more active and this process promotes students’ understanding of specific concepts or problems (Veerman, 2003). Hatano and Inagaki (1991)’s findings show that discussion is a sense-making process for the students because during the argumentative discussion, student present prior understanding, evaluate others' presentations of their understanding, and refine and re-construct his/her own understanding.

In addition, argumentation is the fundamental characteristic of scientific communities and nature of science. Every science community engages with argumentation (knowledge, reasoning, variation in evidence, and patterns of argumentation) to establish or justify knowledge claims (Haack, 2003). Effective argumentation provides an understanding of the natural world to form canonical science knowledge (Akkus, Gunel, & Hand, 2007). In other words, scientific developments are kind of a product of scientific discussions. Argumentation interventions in science classrooms imply the effort to transfer "how scientist work" into science classroom environment (NRC, 1996; 2012). Achieving this transfer in an appropriate way can make students be able to build an understanding of and practice scientific argument for student growth (Duschl & Ellenbogen, 2002). Argumentation includes complex cognition and qualification of scientific communities; thus, the practice of argumentation is important to construct scientific knowledge in science classrooms.

Argumentation is not only an individual activity done through thinking and writing as cognition, but also a negotiated social act (Driver, Newton, & Osborne, 2000; Hand, 2008). Firstly, argumentation processes are individual activity which includes cyclic-cognitive process to produce claims, supporting these claims with evidence, and evaluating the evidence to control the validity of the claims (Choi, Notebaert, Diaz, & Hand, 2010; McNeill, 2009). Secondly, it is a social act in which students offer, challenge, critique, defend, and evaluate through discourse to make sense of the phenomena under study (Berland & Reiser, 2011; Chin &Osborne, 2010). Traditional discourse patterns in science classrooms, as just replicating written text in an oral or written way, do not promote the type of discourse, which scientist initiate to build arguments for scientific claims. Both of the cognitive and social processes are important practices in science to express different viewpoints, cognitive dissonance, and reasoning, all of which can support learning and the scientific knowledge construction (Sandoval & Millwood, 2005; Schwarz, 2009; Chen, 2011). Effective argumentation should employ both social interaction and cognitive dynamic processes.

Language for Doing Science and Argumentation

As a critical component of argumentation and doing science, language is perceived as a critical tool for communicating in science and making thinking visible (NRC, 2000). So, the role of language is not only for communication but also as an active process of refining and strengthening ideas through critiquing and reconstructing of ideas (Wallace & Narayan, 2002). To encourage students to be engaged with scientific argumentation, teachers ought to support students to be involved in "learning to use language, think and act in ways that enable one to be identified as a member of scientific literate community and participate in these activities of that community" (Wallace & Narayan, 2002, p. 4). For this aim, teachers should build situations and powerful instructional strategies in which learners have an opportunity to talk and discuss science in context that looks like real science contexts (Hand, Prain, Lawrance, & Yore ,1999; Lemke, 1990). By doing this, students will have first-hand experiences with related science situations which can include more than one plausible answers and explanations.

As Lemke (1990) stated

> Learning science means learning to talk science. It also means learning to use this specialized conceptual language in reading and writing, in reasoning and problem solving, and in guiding practical action in the laboratory and in daily life. It means learning to communicate in the language of science and act as a member of the community of people who do so. “Talking science” means observing, describing, comparing, classifying, analyzing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, designing experiments, following procedures, judging evaluating, deciding, concluding, generalizing, reporting, writing, lecturing and teaching in and through the language of science (p. 1).

To help students become more engaged learning how to talk in science, students need to be active, teacher domination needs to be decreased, and students’ use of language and interaction through language should be supported.

This view was supported by the recent language-based studies in science education. Language is viewed as a learning tool, and sufficient interventions can promote better engagement for students in the practice of scientific argumentation (Gee, 2004; Yore & Treagust, 2006; Klein, 2006; Prain 2009; Hand, 2008). Lemke (2004) fortifies this idea by stating that the conception of argumentation is building on Vygotsky’s (1978) learning theory and the notion that science is not possible without language, including text, modes of representation, and talk (Gee, 2004, Norris & Phillips, 2003). A teaching period is not just a give-and-take activity between learner and teacher. Students need to learn science as a dialogic form, and also need to find themselves in social interactions in which cognitive processes are emphasized in the constructing of scientific knowledge by using argument structures through language. Unless students can find the science in the dialog, they could learn playing the classroom game, but they will not know how to talk biology or chemistry. They will not question and refine their knowledge through the lesson. They cannot challenge or compare their understandings (Lemke, 1990). Thus, language can be considered as an argumentative process which includes using various forms of language, engaging various representations of language, and working across various social settings.

In argument based inquiry settings, to support learning, students should be able to present and communicate their conceptual understanding and questioning through appropriate use of science language. Writing, speaking, drawing and other forms of representations can take place to communicate and negotiate meanings in science. All these kind of representations exemplify the use of language as a learning tool. By emphasizing the importance of language in science inquiry and teaching, teachers' linguistic awareness should be advanced. By doing so, a teacher can easily modify their verbal communication into the forms for inquiry based teaching and learning contexts, and promote their students to have better inquiry interventions (Oliveira, 2010).

Classroom environments, which provide opportunities for language practices in science learning and representations in various forms as written and oral modes, is essential for learners to develop their understanding of scientific concepts, communication and critical thinking skills and cognitive reasoning (Duschl, 2008). Furthermore, effective argument-based inquiry should support students to use language to negotiate their claims with peers in different learning and classroom settings e.g., individual activity, small group, or whole class (Lemke, 1990; Hand, 2008).

Up to now, the importance of the argument based inquiry and use of language in argumentation is discussed. Because of the advantages of argumentation in science learning and teaching, there can be found multiple inquiry based approaches and techniques which employ argumentation in different level and quality. Thus, the quality and form of argumentation interventions in science education will be discussed hereinafter.

Types of Argumentation Interventions

All kinds of argument promote cognitive and metacognitive processes, and critical reasoning and communication skills (Kuhn, 2005). These general learning skills can advance scientific literacy; therefore, it could be reasonable to think that all kinds of argument support science learning and literacy. Nevertheless, different kinds of argument do not always support vigorous understanding of the culture and practice of scientific communities. Argumentation in science has a form that is specific to scientific communities because the nature of argument is not independent from the community norms. For example, despite the competitiveness of the nature of argument, scientific argument should be collaborative. Scientist argue to examine and compare ideas for advancement of scientific knowledge (Toulmin, Rieke, & Janik, 1984). The collaborative and competitive process of negotiating meaning is a characteristic of scientific argument (Cavagnetto, 2010). Although all kinds of argument are not as effective as those in the science community, the practical question remains whether argument interventions in school science foster scientific literacy.

To deal with this issue, Cavagnetto (2010) completed a comprehensive review study on argument based inquiry in school science, which focused on the generation and evaluation of scientific evidence and explanations by presenting advantageous and disadvantageous. Findings show that argument-based instructional strategies are diverse and not all of them have same impact on science learning. He classified argument-based instructional strategies in K-12 contexts in three categories: socioscienctific, structural, and immersive approaches.

Firstly, socioscienctific approaches (See Seethaler & Linn, 2004; Patronis, Potari, & Spiliotopoulou, 1999) employed argumentation to help students identify the interaction between science and social issues. These forms of interventions require students to first learn science principles and then apply their newly learnings in a social context during an activity, such as role-plays, debates, or written reports. The most beneficial side of these strategies is that students can gain the ability to link everyday issues with science principles; thus, they can be motivational tools to stimulate students to study science. Beside the benefits, the challenge of socioscienctific approaches is that students gain understanding of argument, but not scientific forms of argument. They do not support students in understanding how science knowledge is formed in the scientific community; thus, students cannot understand the scientific pattern of argument and scientific knowledge construction. As a result, students tend to argue in the final debate about moral or ethical position rather than a scientific position.

Secondly, structural approaches (See Osborne, Erduran, & Simon, 2004; McNeill, 2009) aim to explicitly teach the components of a sound arguments and the reasoning processes common in science. To reach these goals, they begin with explicit instruction in argument, and then students are required to apply the argument structure in various science and social contexts. These approaches use explicit instruction of argument components which is believed, can have a positive effect on students' understanding of argument if these components are practiced. In the perspective of disadvantageous of these approaches, firstly, additional time is required to teach argument separately from science principles. Secondly, deficiency of emphasis on students' data to evidence journey can be considered if the aim is students' experience in the practice of science. Most of them provide evidence of facts which need little or no interpretation. By doing so, students do not have opportunities to experience with effectively representing and interpreting data.

Finally, Immersive approaches (See Hand, Norton-Meier, Staker, & Bintz, 2009; Norton-Meier, Hand, Hockenberry, & Wise, 2008; Sampson & Clark, 2007) use argument as a vehicle to learn about scientific principles and practices without emphasizing a particular structure. Instead, they stimulate students to provide support for their arguments. The main emphasis of these approaches is scientific practice by requiring students to reason data to develop evidence, in contrast to "structural strategies." Immersive approach emphasize the transition from data to evidence, which requires high level cognition and is as a key element of science. The advantage of immersive strategies is that they provide two opportunities together: the learning of scientific principles and the knowledge construction practices which occur in science. By doing so, students have experience in the construction and critique of science arguments. The time concern can be a disadvantage of immersive approaches. The instructional period often takes more time compared to other argument approaches. It can be perceived by the teachers as difficult to use frequently and catch the curriculum stream. To overcome the time concern, Wiggins and McThighe (2005) suggest that organizing explorations around big ideas and curricular objectives can stimulate more often use of immersive approaches.

According to comparison of advantages and disadvantages of these approaches, immersive approaches seem more powerful because of requiring higher cognitions, combining scientific principles and knowledge construction practices, and providing solutions to curriculum related to time concerns. In this study, SWH, an example of the immersive strategies, is preferred to examine teacher's questioning patterns in argument based settings.

The Science Writing Heuristic (SWH)

The Science Writing Heuristic (SWH) is an argument based inquiry approaches which is categorized as an example of an immersive approach. The SWH approach is originally an example of writing-to-learn strategy in which students engage in the nature of science by using canonical science principals, and their reasoning strategies, as a framework to build understanding (Prain & Hand, 1996; Hand, Prain, Lawrance, & Yore, 1999; Yore, Bisanz, and Hand, 2003). In SWH Classrooms, meaning-negotiation is supported across format for discussion and writing within science topics. By the time, SWH approach evolved in the shed of research and today its focal point is embedding science argument within the context of implementing inquiry (Hand, 2008).

This approach provides student and teacher frameworks which recognizes the nature of science as inquiry and argument, guides students through activities, and serve students as a metacognitive support during their journey from data to evidence. To achieve this, the SWH provides a template for teachers to enhance learning from laboratory activities, and another template for students to guide science activity and reasoning in writing (Table 1). Moreover, the student's template prompts students to generate questions, claims and evidence to produce an argument based on valid reasoning (Akkus et al. 2007). By doing so, it becomes a tool for generating activities to foster understanding of laboratory activities through negotiation involving both teacher and students (Hand & Keys, 1999).

Table 1. The two templates for the SWH: the teacher template and the student template

The Science Writing Heuristic, Part I A template for teacher-designed activities to promote laboratory understanding.	The Science Writing Heuristic, Part II A template for student.
1. Exploration of pre-instruction understanding through individual or group concept mapping or working through a computer simulation.	1. Beginning ideas - What are my questions?
2. Pre-laboratory activities, including informal writing, making observations, brainstorming, and posing questions.	2. Tests - What did I do?
3. Participation in laboratory activity.	3. Observations - What did I see?
4. Negotiation phase I - writing personal meanings for laboratory activity. (For example, writing journals.)	4. Claims - What can I claim?
5. Negotiation phase II - sharing and comparing data interpretations in small groups. (For example, making a graph based on data contributed by all students in the class.)	5. Evidence - How do I know? Why am I making these claims?
6. Negotiation phase III - comparing science ideas to textbooks for other printed resources. (For example, writing group notes in response to focus questions.)	6. Reading - How do my ideas compare with other ideas?
7. Negotiation phase IV - individual reflection and writing. (For example, creating a presentation such as a poster or report for a larger audience.)	7. Reflection - How have my ideas changed?
8. Exploration of post-instruction understanding through concept mapping, group discussion, or writing a clear explanation.	

Question-Claim-Evidence structure represents the structure of the argument in the SWH approach. Inquiry investigations start with posing question about big ideas (concepts) by the learner in SWH classroom. Based on a question, students' review and test, collect data, construct claims based on evidence, learn what experts and different sources say, compare their findings and sources, and finally reflect upon their arguments to examine how their ideas have changed. During these steps, students are required to constantly negotiate meaning as individuals, in small groups and through whole-class discussions. The public and private construction and critique of knowledge occurs within these meaning-negotiate phases. The impacts of SWH approach is examined with recent study by Chanlen (2013) which findings confirm the positive impacts of the SWH approach on students reported by previous studies, and also includes unique impacts of long-term exposures of the SWH approach.

Questioning to Support Science Learning in Argument Based Inquiry

Learning science is a process which requires a social context to develop understandings and construct meanings (Duit & Treagust, 1998). Learning science in school, as meaning-negotiating and meaning-making, happen within classroom discourse in which the learners and teacher have to have active interaction with each other and scientific principles. Teacher questions are a common part of the classroom discourse (van Zee, Iwaysk, Kurose, Simpson & Wild, 2001) and play an important role in revealing students' prior knowledge. "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" (Chin, 2007, p. 817). Thus, examining teachers questioning will be helpful in promoting students' knowledge construction in science learning.

In traditional teaching methods, the goal of the teacher questions is to evaluate what students know. The question has just one short answer, and students try to recall their previous memorizations or find what the teacher wants. As such, teachers' questions are mostly formed as information-seeking and require low level cognitive skills. At the end of the question-answer period, the teacher approves or rejects the answer till finding the "right answer". Students are not encouraged to articulate their thoughts. Students' challenges of the to the teacher's question are considered as a threat (Baird & Northfield, 1992). The role of the teacher during questioning is to follow a planned agenda to ask a series of questions. Teacher is an authority who has knowledge claims, and the role of the students is to accept these claims without negotiation and debate (van Zee & Minstrell, 1997b).

On the other hand, the role of teacher questioning in constructivist science teaching, inquiry, is to elicit what students' explanations and predictions are, even if their responses are different from the canonical science knowledge. Moreover, teachers encourage students to elaborate their answers and ideas; by doing so, teachers promote students' conceptual knowledge construction. Thus, the forms of the questions are more open and require long answers and explanations and students engage with scientific practices using high-level cognitive skills (Baird & Northfield, 1992). Although the teacher asks questions, s/he is not in control of the discourse as an authority. The teacher responds to students' responses in a neutral rather than evaluative manner. The teacher and students have their own authority to make sense of what others say (van Zee & Minstrell, 1997b; Chin, 2007). The differences between these two approaches is presented in Table 2 which is derive from Chin (2007). These two kinds of traditions reflect different kinds of questioning patterns during teaching process.

Table 2. Comparison of teacher questioning in traditional and constructivist teaching (Chin, 2007, p. 819)

	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
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

Questioning in science classrooms commonly happens in two ways. Firstly, the teacher asks question to check students' understanding and knowledge about the topic (Initiate), listens to students answers (Response), and then gives feedback as to whether the answer is correct or not (Evaluate). This pattern is defined as an IRE structure (Mehan, 1979) or triadic dialogue (Lemke, 1990). This pattern is implemented for recall and low level thinking and represents more traditional approaches like lecturing. However, questioning patterns can also include follow-up rather than Evaluate step. So, the pattern occurs like that Initiate-Response-Follow-up (IRF) (Sinclair & Coulthard, 1975). The follow-up step does not have an explicit evaluation. This pattern encourages multiple responses and supports students constructing knowledge in the inquiry process (Chi, 2007). IRF structure is expanded by identifying the IRFRF structure in which elaborative feedback from teacher is followed by a further response from students (Scott and Mortimer, 2003). This feedback can be a repetition of students' response to encourage students to continue, and elaborate the response. By doing so, the exploration of students' ideas and explanation will be enhanced, and dialogic interaction supports the construction of the knowledge in the perspective of students.

As stated previously, the structure of the SWH approach is Question-Claim-Evidence and the argumentation process starts with a question. Questions promote an argumentative environment and improve critical thinking skills by discussing different ideas and claims. During argumentation, students realize misconceptions and negotiate different ideas, and then choose to support or reject those ideas (Gunel et al, 2012, Chin & Osborne, 2008). Thus, questioning is a significant factor in argumentation. Different types of questions can trigger different types of thinking ability. In the perspective of

Bloom’s taxonomy, while some questions require answers that only involve remembering knowledge, some questions requires high level thinking skills like application, analysis or evaluation. During classroom discourse and argumentation, if questions are aimed at high level thinking abilities, and each answer is followed by high level questions, students will be motivated to negotiate at a high level. While students are discussing around some big ideas, their questions play an important role to encouraging students in using high level cognition. Improvement in students posing question and question styles may improve their meaning-making and knowledge construction.

The student’s style of questioning is strongly related to the teacher’s attitude. If the teacher asks questions to get answers at the knowledge stage, the number of students’ questions decreases (Gunel et al, 2012; van Zee et al., 2001). According to studies on this issue, there is no relation between students question numbers and students understanding, but, there is a relation between their question level and understanding (Harper, Etkina, & Lin, 2003). Thus, high level cognitive questions provide students an opportunity to make connections between their prior knowledge and new knowledge (Cimer, 2007).

A teacher has a vital role in students’ questioning because when a teacher leaves students on their own, students are not willing to ask more questions of each other(Aguiar, Mortimer, & Scott, 2010; Chin & Osborne, 2008). Some findings show that there are more student questions in argument-based inquiry teaching environments and moreover, students tend to ask more questions during their group studies (van Zee, et al., 2001). Students become more active when the teacher is more active. If the teacher ask high level cognitive questions, the class tend to begin a negotiation as whole class or group, or vice versa. (Gunel, et al., 2012). To help students to ask more questions and interact with each other, the teacher needs to create an argument based inquiry environment in the classroom and needs to trigger questioning in the classroom.

Summary

In this chapter, argumentation, questioning and their impacts were presented. Firstly, argumentation and its importance for learning science is provided, and then the language was explained as a learning tool in argument based inquiry settings. Then, while there are lots of implementation of argument based inquiry, to find an appropriate approach, comparison of types of argument interventions were presented. According to these results, The SWH approach and how it can be implemented as an advisable approach were explained. Finally, to provide base for the present research, the role of questioning and teacher questions was discussed.

CHAPTER III

DESIGN AND METHODS

The purpose of this chapter is to provide a methodological framework for the study. First, the methods used in the study will be described, and next, the SWH project in Turkey and its participants. In data collection section, the type of data sources will be reported. The data analysis section consists of two phases, an examination of the writing samples, and video recordings and transcriptions, with definition and discussion of Bloom's taxonomy and Initiate-Response-Evaluate (IRE) model. The data analysis section will close with providing reliability evidences.

Research methods

This study used qualitative methods to address research questions with including numeration aspects. Firstly, a preliminary study analyzed the SWH writing templates, which were scored by using Jang's (2011) scoring matrix, to compare six teachers. Two teachers were selected based on the preliminary study's results. The feature of these teachers is that one of them had the highest score and the other one had one of the lowest score according to writing scores of their students. After this initial analysis, the main analysis is conducted. The goal of the main study was to investigate the amount of teacher talk during each class period, the number of teacher talk turns, the number of teacher questions, the dispersion of teacher questions according to Bloom's taxonomy, the lesson organization (purposes of classes) and classroom talk patterns. These were analyzed by using video recordings of science classes led by each of two teachers. The videos were transcribed for two purposes: (1) to code teacher questions according to Bloom's taxonomy and (2) to code talk patterns based on the Initiate-Response-Evaluate

(IRE) model. Descriptive statistics, tables and plots to analyze the data were used to present numeration aspect of the study.

Context

Participant teachers were enrolled in a professional development (PD) project (2010-2013) focusing on The Science Writing Heuristic as an argument-based inquiry approach. The main purpose of this project was to improve teachers' content knowledge, change their beliefs about teaching and learning, and support their pedagogical implementations. The pedagogical implementations involved more student-centered classrooms and more active students rather than teachers during learning period. 30 teachers participated in the project and the PD sessions which took place right before the start of each semester. In the present study, pseudonymous were used for confidentiality. the writing samples were collected in the first year of the project, and the video recordings belong to second year of the project.

Teachers

Salih

Salih was an experienced teacher who has taught as a science teacher at the secondary level for 11 years. His school is located in the Mid-Anatolia region in Turkey and at the time of the study he was in his 3rd year in the same school. He taught 6th, 7th, and 8th grades science, which included Earth Science, Life Science and Physical Science. There were 28 students in his classroom and this number was below the average classroom size in Turkey. The socioeconomic status of his students was slightly higher than middle class in Turkey. Salih attended all PD sessions before the video recordings. According to one of project researchers, he was eager to implement the SWH approach in his classroom but the implementation level is not as intended.

Yasin

Yasin was also an experienced secondary school teacher who had spent 16 years teaching in the Southeast region in Turkey and was in his 6th year in the same school. He taught Earth Science, Life Science and Physical Science to 6th, 7th, and 8th grades. The number of students in his classroom was 35 which was the average classroom size in Turkey. The socioeconomic status (SES) of the students' families was below the middle class in Turkey. He attended all PD sessions except the third one. During the third PD session, as a part of the PD, the participants and researchers watched a video of his SWH implementation and discussed it with his consent. He let the coordinators show his video to other participants, which they recorded that discussion and sent to him. By doing so, although he did not attend that session, he was informed about it.

Table 3. Participant teachers and their background data

	Number of students	**Experience (School/Total)**	**Teaching**	**Grade**	**Experience in SWH and Year**
Salih	28	3 / 11	Earth Science Life Science Physical Science	6,7,8	2 / 2012
Yasin	35	6 / 16	Earth Science Life Science Physical Science	6,7,8	2 / 2012

Data Collection

Data were collected from argument-based inquiry implemented classrooms in two different forms that are writing samples and video recordings. Writing samples were collected in the preliminary study. After conducting preliminary study, video recordings were made of the teachers in the classroom for the main study.

Writing Samples

Writing samples were collected in the first year of the SWH project in Turkey. These samples included SWH templates where the students write their (1) questions, (2) beginning understandings, (3)their tests and results about the question (results of experiment), (4) claims and evidence, (5) comparisons with friends, (6) comparisons with three different sources and their initial claims and evidence, and (7) their reflections. A SWH template was completed for each big idea in a unit. The SWH templates are structured reading frameworks created by Jang (2011). The difference between the original reading framework and the structured reading framework is a comparison between outside sources and the students' claims and evidence. Although the original reading framework consists of only one part which asks students to describe outside sources without any guidance, the structured reading framework includes three different areas where students can take notes about each source and a separate section below the notes where students can compare the information with their claims and evidence.

Table 4. Writing samples and related data

Teacher	Grade	Unit	Number of writing samples	Semester in SWH
Salih	6	Matter	28	2
Teacher 2	7	Force and motion Human and environment	19	2
Teacher 3	6	Heat and matter	20	2
Teacher 4	6	Reproduction, growth and development	12	1
Teacher 5	7	Human and environment	10	2
Yasin	7	Body system	23	2

The structured reading framework provides guiding questions for taking notes and comparing. The first part (notes from source) prompts students to record information from the source, and the second part (compare and contrast) requires students to compare their recorded information to their beginning ideas, claims and evidence. Jang (2011) notes that a “reading phase allows students to negotiate with what they read from various sources, and to sharpen their conceptual understanding of the big ideas of the unit” (p. 35). As a conclusion, the researcher of the present study believes that students learns negotiation from the environment, and if the classroom environment supports a good negotiation during classroom activities, students have a better ability to compare and contrast ideas.

Video Recordings and Transcriptions

Video recordings were collected in the second year of the project. Each teacher was video-recorded during two class periods while teaching one big idea. Four videos were examined. A project researcher recorded the lessons given by Salih, and a student recorded the first part of the lesson given by Yasin, who took over during the experiment and claim and evidence presentations. Each class period was 40 minutes, but the lengths of the videos vary as shown in the table 5. They were different length because of the some recording issues. The researcher transcribed the video recordings word by word. Transcriptions were used for more detailed examination to the talk patterns in the classroom.

Table 5. Video recordings and related data

	Grade	Unit	Number of students	Lengths of videos 1st period/2nd period	Semester in SWH
Salih	7	Electricity	28	26” 25’/32” 43’	4
Yasin	8	Sound	35	34” 50’/31” 59’	4

Data Analysis

Data analysis had two phases: (1) examining writing samples and (2) examining video recordings. The Students’ writing samples were scored and then the teachers were compared based on average writing scores. After classifying the two teachers as either low or high based on their students writing scores, the two teachers’ video recordings were collected. These video recording were examined firstly by watching and then by transcribing.

Phase 1: Examination of the Writing Samples

The SWH templates, which has the structured reading framework, were collected from a six teachers who were participated in the project. These samples were scored according to Jang's Scoring Matrix for the Reading Framework (table 6). The scoring matrix has three parts. The first part focuses on the use of information and examines students' notes about the sources. The credibility of the source and the relation between the notes and the students' questions and the big idea are scored. The second part focuses on the student's comparison of the source and their own understanding, claims and evidence and examines the quality of the comparison. The degree level of the student's recognition of the similarity and difference between their notes on the sources and their claims and evidence, and the accuracy and adequateness of the comparison were scored on a 0-3 point scale. The third part focused on the number of modes used by student. The scoring matrix used to investigate the quality of students writings in the perspective of their implicit negotiation which can be reflection of their learning of scientific process in the classroom.

Table 6. Jang's (2011) Scoring Matrix for the Reading Framework

Component	Subcomponent		Score
Use of Information	Credibility	0	The information from source is not credible
		1	The information from source is credible
	Connection to Big idea	0	No relationship between the information from the sources and big idea
		1	The information from the source is weakly related to the big idea
		2	The information from the source is related to the big idea
		3	The information from the source is strongly related to the big idea
Quality of Comparison	Connection to Claim & evidence	0	No connection between the comparison and claim & evidence
		1	Weak connection between the comparison and claim & evidence
		2	Moderate connection between the comparison and claim & evidence
		3	Strong connection between the comparison and claim & evidence
	Accuracy of Comparison	0	Inaccurate and invalid comparison
		1	Weakly accurate and valid comparison
		2	Accurate and valid comparison
		3	Sophisticated and strongly valid comparison
Number of Mode		Number count	

After scoring a number of students' samples from six teachers, the researcher found a difference from teacher to teacher: the average scores of students' writings were differentiated from teacher to teacher. While some teachers' students had good scores, others had low scores. The researcher hypothesized that this was because of differences during classroom implementation of the SWH approach. The first phase triggered the second phase of the research. To examine what is happening in the classroom, video recordings were collected and transcribed.

Phase 2: Examination of the Video Recordings

Videos were examined to see how much time the teacher talked, how much teacher had turns of talk, how many questions the teacher asked, the quality of questions, how the teacher organized the class period, and how the classroom talk patterns happened. In the first part of the Phase 2, data was analyzed by calculating numbers, percentages and rates. The amount of teacher talk was measured with a stopwatch and recording these measurements separately for each class period. And then, the number of teacher's talk turn was counted from the transcriptions. The transcriptions were coded to identify, firstly, questions, and next, the quality of questions. Each question was coded using Bloom's taxonomy to identify quality. Finally, the number of each type of teacher responses were counted and teachers were compared to other by using percentages and rates according to their own total talk turn, and questions.

In the second part of the Phase 2, the data was analyzed according to how the class was organized and the talk pattern. The organization of the class period was described for each teacher and recognized the characteristics. The last step was an examination of the classroom talk pattern for each teacher and each class period. During this step, the Initiate-Response-Evaluate (IRE) model was used to code transcriptions. The researcher focused on not only the teacher's, but also the students' initiations and evaluations. Some parts of the classroom conversations were quoted for the last part of the analysis to show specific examples.

Bloom's Taxonomy

Bloom's taxonomy was developed as a method of classifying educational objectives for student performance evaluation by psychologist Benjamin Bloom and colleagues in 1956 (Gage and Berliner, 1998). Bloom's taxonomy focuses on, specifically, the cognitive domain of learning and named as a cognitive-domain taxonomy. Although it has been revised over the years, it is the only one that has been widely utilized and discussed in education (Gage and Berliner, 1998).

The Bloom's taxonomy consists of six developmental categories in a cumulative hierarchical framework: knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom, 1956). Each next category requires more complex cognitive skills than the previous one. The first step, knowledge, is the ability to recall, recognize, memorize, repeat information, and list. In the comprehension category, students are able to classify, describe, identify, and explain information. Application, the third step, is the ability to use rules, abstractions, ideas and principles to interpret, demonstrate, and solve problem. In the fourth category, analysis, students are able to examine, distinguish, categorize, compare and contrast multiple sources of information. In the synthesis step, students are able to combine, compose, hypothesize, plan, develop, design, and produce based on their knowledge, application, and analysis. Finally, students are able to make intellectual judgments, arguments, critiques, supports, and defenses whether methods and materials satisfy criteria. This step is evaluation and the highest level of cognitive ability.

In the present study, Bloom's taxonomy was used to codify the teacher's questions to reveal in which level teacher's questions belonged to. The teacher's questions promote an environment of argumentation and improve critical thinking skills by discussing different ideas and claims. To conclude, the researcher of this study believes that there is a relationship between students' negotiation in writing and the teacher questioning level.

Initiate-Response-Evaluate (IRE)

IRE was defined by Lemke (1990) as a form of classroom interaction. Interaction starts with a question that is initiated by the teacher, the students responds, and finally the teacher evaluates the responses to end the interaction. The teacher creates an interaction pattern in which the teacher is the moderator of discussion and judge of the students' answers. The IRE model limits students' contributions to high-level classroom discourse and argumentation because of requirement to answer question with the "correct" response, and results in a monologue interaction. "Many analyses of IRE participation structure have suggested that it leads students to perceive that learning consist of memorizing a set of predetermined, non-negotiable facts." (Hoadley and Enyedy, 1999, p. 4).

To increase student learning, conversation may begin with teacher initiation but continues with student-to-student interaction before the teacher responds. The goal of the teacher's response should not be evaluation, but may be clarification, addition or the next initiation. By taking this approach, classroom interaction turns into dialogue and it leads students to become self-regulated and reflective learners (Wilson & Smetana, 2011). The classroom dialogue pattern may be like this: "I (teacher)-R (student)-R (s)-I (s)-R (s)-R (s)-E (s)-I (s)-R (s)…. –R (t)-I (s)-R (s)-R (t)…" Not only response, but also initiation and evaluations comes from the students. Thus, a skilled teacher should use the second pattern rather than the IRE pattern.

Validity and Inter-rater Reliability

To assure the reliability of the study, in first phase, the researcher, a doctoral student from College of Education at the University of Iowa and Dr. Jang, the developer of the scoring matrix for the reading framework, met seven times to discuss scoring the SWH templates using the Jang's structured reading framework scoring matrix. The doctoral student in science education has been working on SWH templates more than one semester, so she is experienced in scoring rather than the researcher. After the first five meetings, the doctoral student and researcher scored the SWH templates together, with an inter-rater reliability score of 0.84. The disagreements were discussed, and the researcher and others had an agreement on these points. After the training for scoring, the researcher scored Turkish writing samples.

For phase 2, the researcher met twice with another doctoral student in science education at University of Iowa discuss Bloom's taxonomy and the IRE model. The researcher and doctoral student coded one of the four class periods separately with an inter-rater reliability score of 0.85. Afterwards, the researcher scored SWH templates using the structured reading framework scoring matrix, and coded other three videos using Bloom's taxonomy and IRE model.

Another point for this study is language issue. All type of data are in Turkish. For scoring, the researcher was trained in English, had an agreement on scoring, and then he scored Turkish writing samples. For the video recordings, the researcher coded the transcriptions in Turkish. To present some excerpts from transcripts, the researcher translated them in English. The translation of the excerpts were checked by a Turkish doctoral students in science education program. Because the researcher is native speaker of Turkish language, all the transcriptions were not translated into English. The coding and scoring were done in original language of the samples.

Summary

This study compares the classroom environments and discourse patterns of teachers whose students have high scores and low scores on the SWH by observing lesson organization and coding the transcription of videos of two class periods for each teacher. In this chapter, the methods used in study, the context of the study, the data collection and data analysis were provided. The results of the data analysis will be reported in the next chapter.

CHAPTER IV

RESULTS

This chapter will describe the two phases of this study: the analysis of student writing samples which will be used to classify six teachers, and the analysis of classroom video recordings of two teachers (one low and one high level) which includes four different aspects: teacher talk time, quantity and quality of questioning, lesson organization (purpose of class), and conversation patterns. Student writing samples will be used to decide the teachers' level of implementation. Teacher talk time will be examined to provide overall insight into the class period. A questioning pattern analysis investigated the quality of teachers' questioning based on bloom's taxonomy. A lesson organization analysis will explain how the teacher organized the classroom and students for argument based inquiry. Finally, a conversation pattern analysis will focus on each teachers dialog pattern using Lemke's triadic dialog pattern.

Phase 1

Results of Writing Samples

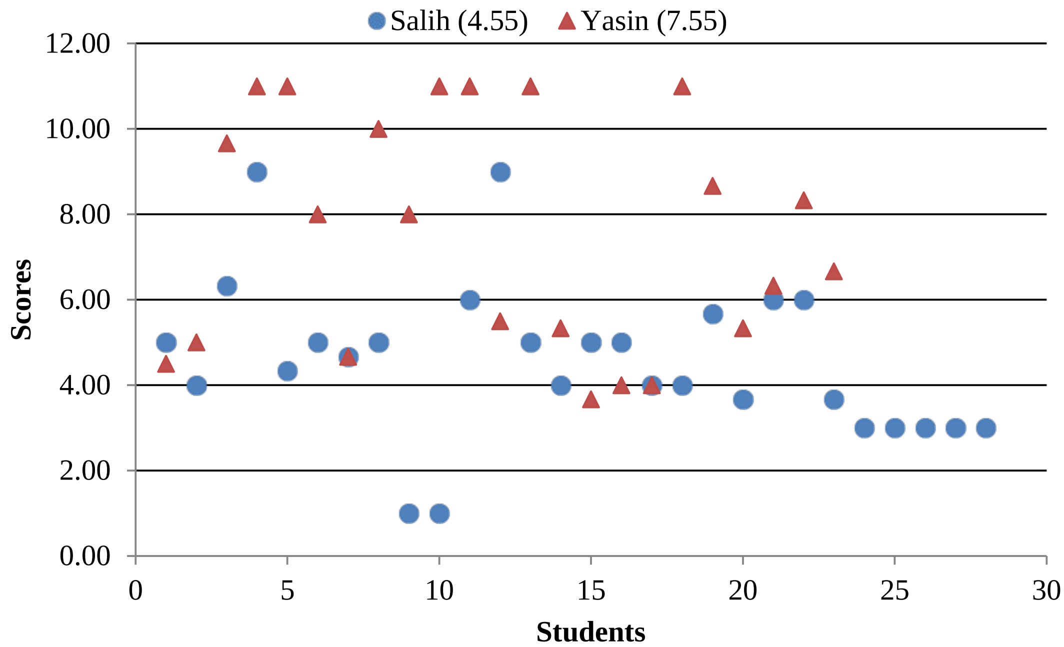
The writing samples examination was conducted with six teachers and their average scores were compared with each other (Table 7). The scoring focused on how students make comparison between their Question-Claim-and-Evidences and notes from various sources. Their writing scores showed significant differences between teachers and the result table is below.

Table 7. Average scores of students' writing samples for each teacher

Teachers	Average writing scores (out of 10)
Salih	4.54
Teacher 2	5.41
Teacher 3	5.5
Teacher 4	5.93
Teacher 5	7.38
Yasin	7.55

Based on these results, two teachers were selected to examine their classroom environment. Yasin had high scores compared to Salih. To make certain that the reason for the students' scores being high or low was because of the teacher, the distribution of the students' scores for each teacher were examined as showed in the figure 1. Salih's students had similar scores except for two of them who had higher scored. These high scoring students were around the average for Yasin's students. The significant point is that Yasin's low scoring students are around the average for all Salih's students. This figure gives some clues that these two teachers may have had a different implementation of the SWH Approach in their classrooms. Regarding these results, Yasin is identified as a high level teacher and Salih is identified as a low level teacher. To uncover what is happening in the classroom, teacher's talk time was initially examined.

Figure 1. Dispersion of the students' writing score from two teachers



Phase 2

Comparison of Teachers' Talk Time

Teacher talk time was measured using a stopwatch. The results are presented in Table 8. The teacher talk analysis focused on the percentage of each lesson that the teacher talked because the length of each lesson were not same. Yasin, a high level teacher, talked more than Salih who is a low level teacher (Table 8). While Salih talked for twenty-four percent of the two class periods, Yasin's talk time was twenty-seven percent. These results could be assessed as showing that both of the teachers have similar talk time; but there is a great difference when a more detailed analysis of each class period was undertaken (Figure 2). While Yasin's talk time (32%) is two times more than Salih's talk time (15%) for the first period, in the second period, the percentages of teacher talk time are completely opposite: Yasin (21%) and Salih (31%).

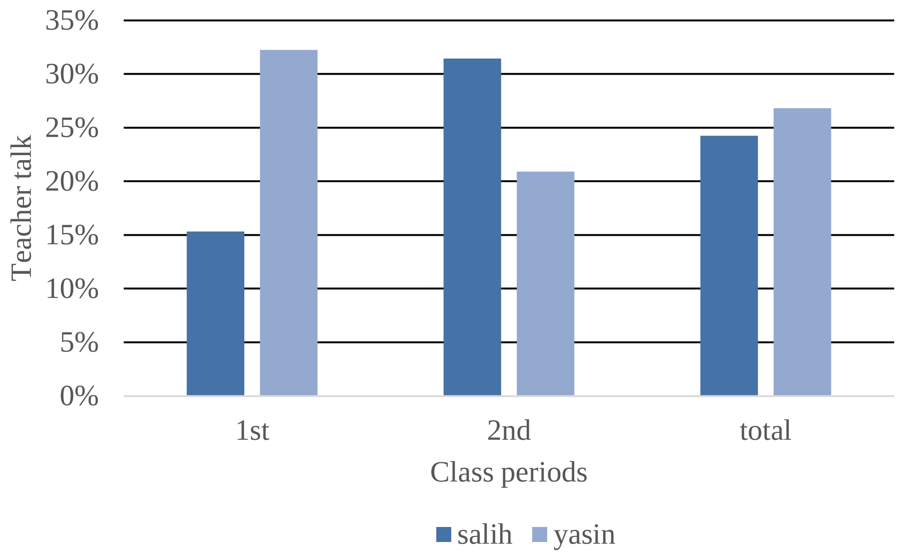
Table 8. Teacher talk time and proportions

	First Period			Second Period			Total		
	Teacher Talk	Video Length	%	Teacher Talk	Video Length	%	Teacher Talk	Video Length	%
Salih	4:03	26:25	15%	10:17	32:43	31%	14:20	59:08	24%
Yasin	11:14	34:50	32%	6:41	31:59	21%	17:55	66:49	27%

The reason for this difference is the teacher's teaching approach. Yasin's endeavor, in the first period, was to trigger students' engagement with the topic before starting their experiments, and it required lots of teacher talk and questioning to unpack prior knowledge and develop experimental questions. Moreover, during this process, students became familiar with the topic and they picked their own experiment questions. On the other hand, Salih did not assign any time to talk and discuss the topic. The students just started to do their experiments from their textbooks.

For the second period, Yasin mostly let his students talk and discuss their experiments and findings, therefore his talk time was decreasing. In contrast to the first period, Salih had more talk time in the second class period, because while students were presenting their findings, they had not had time to discuss or ask each other questions. For this reason, Salih needed to intervene and support them by asking questions and explaining the topic. The reasons for the teacher talk time differences are mentioned briefly here, but there is another reason for lesson organization and purpose differences between two teachers in more detail below.

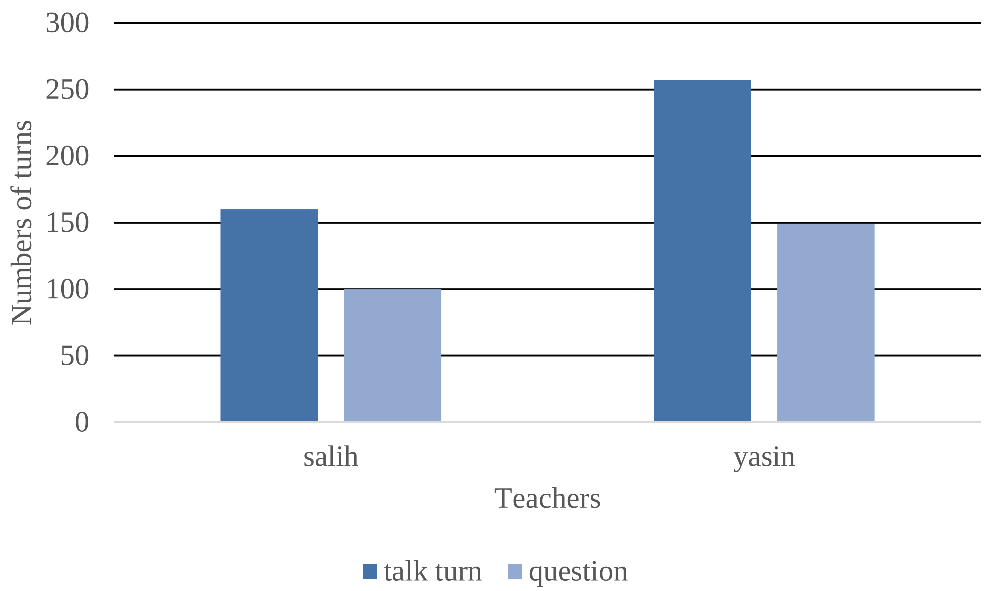
Figure 2. Percentage of teacher talk



<u>Quantity of Teacher Talk and Questions</u>

In this level of analysis, the researcher wanted to examine how teacher questioning is important and is shaped during the teaching process. Firstly, the teacher talk frequency and the number of questions were counted; then, to assess the quality of these questions, they were coded based on Bloom's taxonomy. The results (Table 9) show that, firstly, for the high level teacher, Yasin, the number of talk turns were 257 which was higher than the low level teacher, Salih -160 (Figure 3). It was 1.6 times greater than for the low level teacher, and also the number of questions asked was similarly high: 1:1.5 (100/149). Secondly, when teacher talk turns and question numbers were compared, it is easy to see importance of questioning in argument based science classrooms because the teacher talk mostly included questions. The percentage of talk that consisted of questions was similar (Salih: 62%, Yasin: 58%), and independent of how much they talked (Salih: 100/160, Yasin: 149/257). On average, sixty percent of teacher talk consisted of questions.

Figure 3. Comparison of each teacher talk turn with question number



When we looked at the distribution of teacher questions during the first and second periods, there was a great difference (Table 9). Although Salih, in the first period, asked forty-four questions, which represented forty-four percent of his total questions, Yasin asked a hundred and four questions representing seventy percent of his total questions. In the second period, Salih asked fifty-six (56%) questions and Yasin's number of questions was forty-five (30%). While Salih's question number increased slightly from the first period (44) to the second period (56), Yasin's question number sharply decreased (from 104 to 45). Yasin had intensive questioning in the first period but, in the second period, he held himself back to let his students discuss with each other.

These figures represent similar results for teacher talk time measurement, and also there were similar results for teacher talk turns. As a results of examining the quantity of teacher questions, the researcher wanted to examine quality of teacher questioning.

Table 9. Teacher questioning quality based on bloom's taxonomy

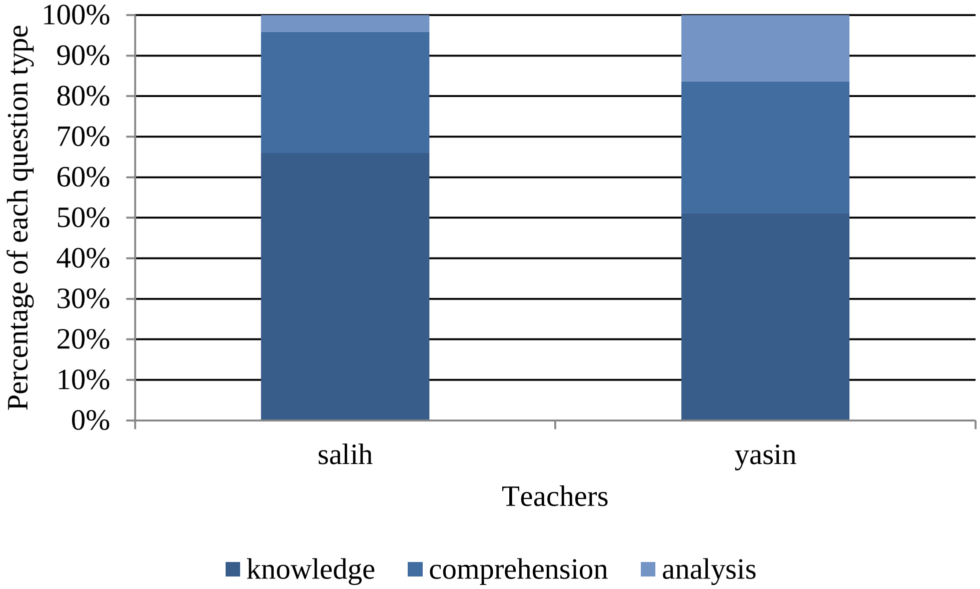
	Salih			**Rate**	**Yasin**		
	1st	2nd	total		total	1st	2nd
Teacher talk turns	41	119	**160**	1:1.6	**257**	177	80
Total questions	44	56	100	1:1.5	149	104	45
Knowledge	29	35	64	1:1.2	75	49	26
	66%	63%	64%		50%	47%	58%
Comprehension	10	19	29	1:1.7	48	35	13
	23%	34%	29%		32%	34%	29%
Application	2	0	2	2:1.0	1	1	0
	5%	0%	2%		1%	0%	0%
Analysis	3	1	4	1:6.0	24	19	5
	7%	2%	4%		16%	18%	11%
Synthesis	0	0	0		0	0	0
	0%	0%	0%		0%	0%	0%
Evaluation	0	0	0		0	0	0
	0%	0%	0%		0%	0%	0%

Quality of Questioning

The quality of teacher questions was examined by using Bloom's taxonomy as a framework. Teacher questions were coded according to what kind of answers they required. I focused on answers while coding the questions because most of the questions, at first, seemed to be knowledge level questions, but when we assessed them in their context, e.g. by focusing on the answers, the quality code of the question changed because they required answers of a higher cognitive demand. The coding results and their percentages are provided in table 9. Despite including 6 categories of Bloom's taxonomy in our analysis, only three categories, knowledge, comprehension and analysis, were found. Although application level questions were found, these are excluded because they represent just one percent of questions. These results are similar to Diaz's (2011) dissertation study. Diaz analysis show that he found just three level of question: knowledge, comprehension, and analysis during his codings. As a result, the quality of questions was examined under three categories: knowledge, comprehension, and analysis.

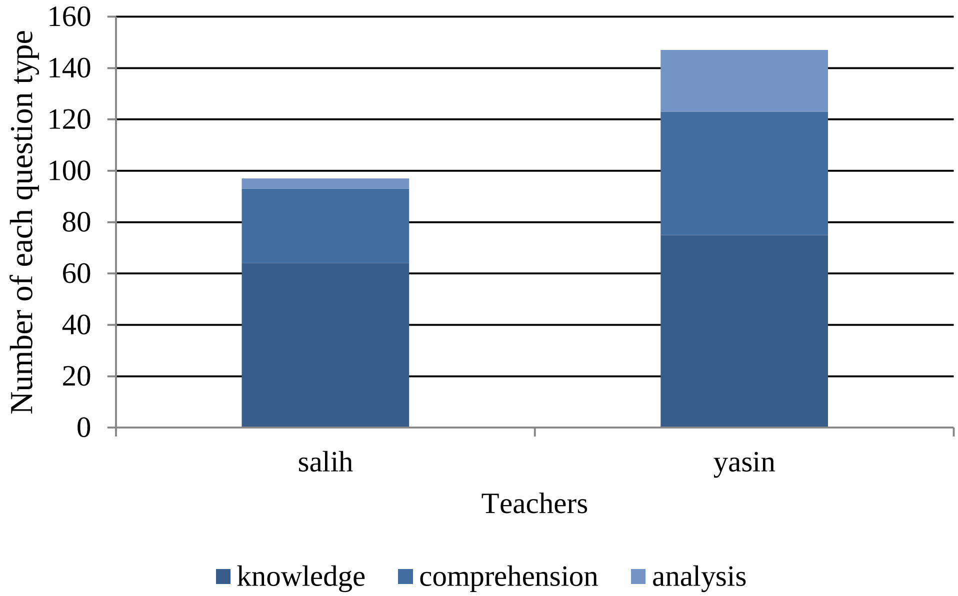
Knowledge level questions, from the perspective of Bloom's (1954) description, examines whether the teacher asks for memory (recall facts) of previous learnings. Comprehension level questions require answers which include understanding of facts and ideas by comparing and stating the main ideas. Analysis level questions require that students break their knowledge into pieces by identifying and finding evidence to support generalizations. All of the questions in the transcripts were coded and results are provided in table 9. The results show that overall the teachers mostly preferred knowledge level questions, with comprehension level questions next, and finally, analysis level questions. Questions which require higher order cognitive ability were asked less often. When we look at the each teacher separately and compare, the difference will be seen more clearly.

Figure 4. Distribution of percentage of teachers' question type



While Salih's questions included sixty-four percent knowledge level, twenty-nine percent comprehension level and four percent analysis level questions, Yasin's questions consisted of fifty percent knowledge level, thirty-two comprehension level, and sixteen percent analysis level questions (Figure 4). The main differences, as seen, independent of how many questions were asked, is that Salih's questions mostly required more low level answers compared to Yasin's questions. The biggest difference emerge at the analysis level and knowledge level. Yasin's analysis level questions increased and knowledge level questions decreased compared with Salih. When we looked at the ratio of each question type of both teacher, the rates are for knowledge 1:1.2, for comprehension 1:1.7, and for analysis 1:6.0 (Figure 5). Examining both percentages, numbers, and comparison rates shows that Yasin’s questions required more higher-order cognitive abilities than Salih’s.

Figure 5. Distribution of number of teachers question type



If we look at each class period and compared the two teachers question types, the percentage distribution of question type for each teacher shows similar results (Figure 6). There is no large difference between the two class periods for each teacher, but there is some fluctuation. If we look for the numbers of questions for each period, there is a bigger fluctuation in the first and second periods (Figure 7). Moreover, overall the number of questions asked by Yasin was higher than Salih.

Figure 6. Percentages of each period's distribution of question quality

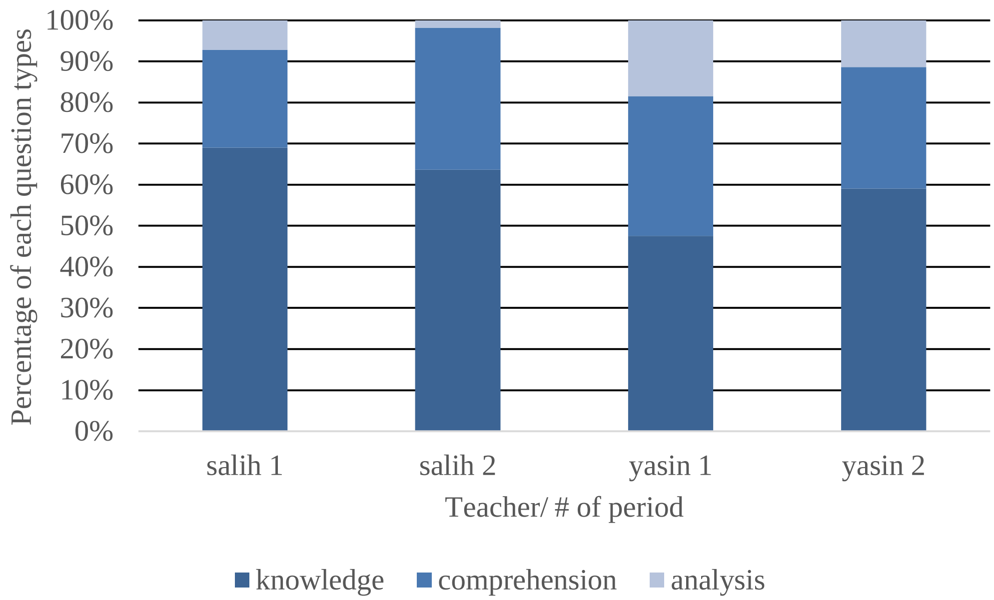
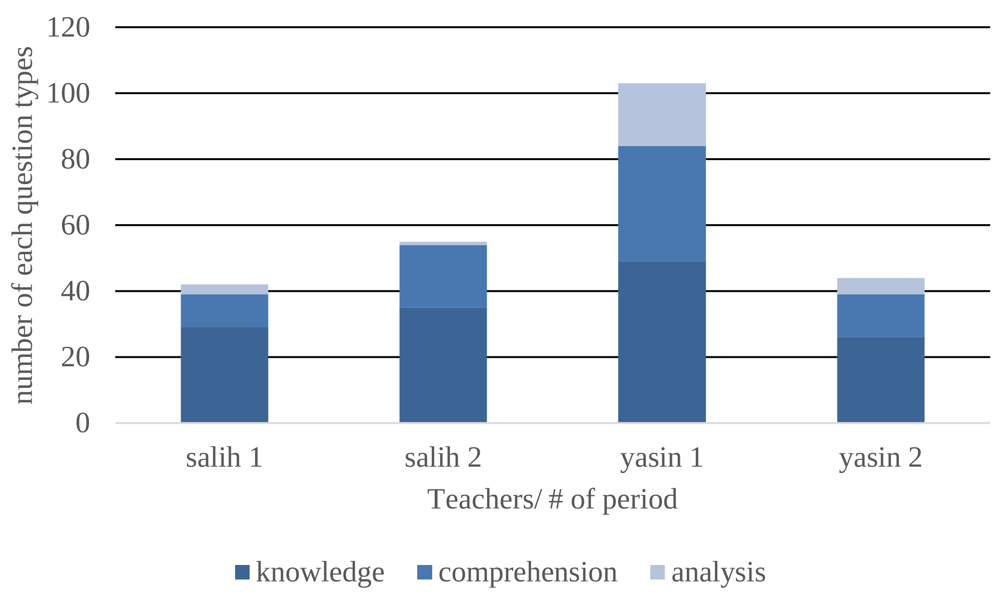


Figure 7. Numbers of each period's distribution of question quality



Organization of Lesson

Salih

1st class period

Salih introduces the lesson: “static electricity” and explains what students will do. There is no Q-A session. Students work as groups and each group has their own materials to do the experiment, which is defined in the textbook. So, all groups do the same experiment.

Testing and observing

Students started to do their experiment with their group members without any question, claim or evidence. While they are working, the teacher strolls around and ask questions: “what is your aim?” “What do you want to see by doing this?” When students need help, the teacher joins them and assist with their experiment. Moreover, at some points, he leads them to try new things and explained what they would do. He intervened to help with and interpret the experiments. During this period, the students were free to take notes or not.

2nd class period

Students continued doing their experiments. While some groups completed what was written in the textbook, some did extra research to reach new claims and evidence. After the first ten minutes, the first group wants the teacher to start the presentation and discuss the findings with rest of the class. The teacher asks the students whether they are finished. After their responses, the first group starts to present their experiment, claims and evidence (no question).

Group presentation and whole class discussion

Each group presented their experiment, what they did, how they did and what they found. They explained their claims and evidence. In generally, however they forget to describe their claim and evidences after explaining the experiment. In this situation, the teacher reminds them to describe their claims and evidences. The reason why they did not remember may be that they did not fill out the SWH templates. After the presentation, the teacher led students to ask questions of the group. In some situations the teacher was actively involved in the discussions and asked more questions than the students. Because the teacher had not unpack the students' prior knowledge before starting the experiments, the students had some problems explaining the reasons for the static electricity and so the teacher tried to do some brain storming to show them the reasons but these endeavors were not enough to reach the goals.

Yasin

1st class period

Unpacking prior knowledge and deciding test question

Yasin starts his class with questions to unpack students' prior knowledge about "sound". There is a whole class Question-Answer session. The teacher asks questions and depending on the students' answer, he tends to restate their response and continue to ask questions without giving any feedback about whether they are correct or not. After a while, the teacher asks students to create their own questions. At this point the teacher organizes an argument with the class about which questions are good questions. The class came to the agreement that a good question should be testable. After each student asks a question, the class decides whether the question is worth testing and writes it on the blackboard. Afterwards, the students create groups and each group selects a question to test and generate a claim and evidence.

Testing and observing

In the second part of the first class period, students created an experiment to answer their question. While designing the experiment, they are free to choose whichever method they want. During the experiments, the teacher strolls between the groups and asks questions about their experiments, claims and evidence, but he avoids giving exact answers about their procedure. With these questions, he tries to open a new direction when they are stuck. In this period, students are responsible for filling out their SWH templates.

2nd class period

Group presentation and whole class discussion

There are five groups and each of these groups had a presenter to present their question, experiment, claim and evidence. After each presentation, the teacher directs other groups and students to ask questions to that group. Students were eager to ask questions and discuss with each other. During this period, the teacher is not greatly involved in the process, but he acts as an organizer and moderator for the class discussion. At some points, he asks for clarification by using phrases like “I did not understand; did you mean this?” By doing so, he avoids giving feedbacks which includes the “right” or “wrong” answer.

Conversation Patterns

Salih

At the beginning, the teacher introduced the topic and the students were responsible for conducting the experiment which was written in their textbook. Students also knew what they would do in the class before beginning. For this activity, the students brought their experimental tools with them. The students began their experiment without discussing or talking about the topic. They did not explain or reveal their prior knowledge of static electricity. At the beginning, some students did not realize what they should do, and why they were doing it.

Teacher only questioning

When students started to do their experiments, Salih was strolling between groups and just asking questions (initiate) without waiting for a response from the students. He did not expect students to answer.

- Firstly, what will you find?
- What do you want to find?
- What is our aim?
- How will you find?
- What will we examine?
- Think! What will we have?
- How can we design the experiment?
- Yes, you did; but why you are doing this?
- What is your question?

These were the initiations and they were repeated more than once. Salih never encouraged the students to respond. Thus, there was no conversation between Salih and students at the beginning of the class period.

Teacher interventions as a director

During the experimental period, students gathered some results and they wanted to show their results to the teacher. At this point, he appeared to evaluate and give some directions to continue the experiment. During this phase, if the teacher had any initiation, he said:

- This decreased, as you see they are pushing each other. At the beginning, it was pulling now it is pushing.
- It's good, it's good. Go on.
- Your friends touched them each other and observe. At first, they look for without touching and then with touching. After touching, what happened?
- Do this from the top side! … If you hold it like this, it will be better, isn't it?

He generally did not let students explain what they did in their experiment and intervened to give directions. The reason for this situation may have been that students were conducting the same experiment which was textbook-based, and the teacher knew what they were doing; therefore he intervened only to give directions. If the teacher did not know what their experiment looked like, he could not give directions and he would need to ask how they proceeded. One of these directions in a conversation is described below:

Student: We found!
Teacher: What do you see?
Student: It is pulling.
Teacher: Try it! Let's see! You don't need to bring it closer.
Student: It is pulling.
Teacher: Try from this side, or from the top. Hold straight.

Teacher-student initiations in a conversation

In the last part of the first period and during the presentation and whole class discussion, Salih initiated discussion and waited for a response from students. Students had different answers and explanations but they were just repeating what they did and could not reach any conclusions. The students could not make connections between their experiment and the topic. When they did not have any suggestions, the teacher evaluated and gave answer to his own questions. In this manner, the conversation pattern was this form: I (initiate)-R (respond)-...-I-R-E (evaluation). This situation is common in the presentation and whole class discussion period; for example,

> (During the experiment, students are bringing together two items.)
>
> Teacher: what's happening now? (I)
> Student: when we bring together them, they are pushing each other. (R)
> Teacher: what happened now? Shortly before, they were pulling each other. (I)
> Student: teacher, both of them… (R)
> Teacher: what is differentiated? What did you see? (I)
> Student: teacher, one of them is neutral, other is charged. When we bring closer, they pull each other. But now (he means touching), the electrons passed one to another. (R)
> Teacher: how did electricity pass to another? (I)
> Student: we did that. (R)
> Teacher: touch (R by teacher)
> 2nd Student: the positives passed on it. (R)
> Student: yes, because electricity passed on it. Therefore they split up. (R)
> 3rd student: teacher, but the positives cannot pass, therefore negatives … (R)
> Teacher: we don't know the type of the particle, do we? But we know it passes. (He goes another group) let's look in here, yours is OK. Let's look. Where are we looking? Touch it to another. A little touch. (E-I)

Salih let students respond, but when they did not give the exact answer he had in his mind, he answered the question and gave orders to change the experiment's direction. In some part of the conversation, students became involved and had different responses and presented their ideas but Salih did not let them continue and figure out the next step.

He intervened and responded.

The use of "Restate"

Salih, in some part of conversation, tended to restate the students' responses. While doing this, he generally restated the sentences with the answers he wanted. After restating, he presented it as the right answer:

- Ok, I wonder that: one of them is neutral, the other is charged with electricity. When you bring closer them to each other and then they pull each other. We shall understand this completely.
- Ok. For example, you said paper is neutral. Charged pull the neutral, doesn't it?

When Salih asked question in this way, students seemed to get the idea that the teacher was right. Therefore they did not tend to continue the conversation.

Conversations triggered by students

In Salih's class, initiations mostly came from the teacher. In the first class period, there were no students' initiations and evaluations. If there was an initiation and evaluation, it came from to teacher. In the second class period, after students presented their findings, claims and evidence, during the whole class discussions the teacher asked the class whether they had questions for the presenting group. The students did initiate the asking questions of their friends, but this was not frequent. The students initiated discussions or questions eight times and evaluated twice during the presentations and whole class discussion periods. When these numbers are compared with Salih's initiation and evaluation, they are very small. As seen, the whole class session was dominated by the teacher.

The way of presentation

During the students' presentations, students did not have any framework to present their claims and evidence, and how they test; therefore, they presented what they did without any order. When they forgot any of the question-claims-and-evidence, the teacher intervened:

- What is your claim?
- Why did you do this?

Students generally presented their experiment and how they conducted it. They talked about their claims at some point but not often. This may be because of not using the SWH templates and not having any cognitive preparation for the experiment. They did not start with a question. They were supposed to investigate something about static electricity during their experiment and decide on a question, but they were not explicitly told to come up with their question, claims and evidence. This can be inferred from the teacher's question at the beginning of the class. Although, the teacher did not mention claims and evidence before and during the experiment, during the presentations, he asked for their claims and evidences.

Yasin

Unpacking prior knowledge by question and answer session

Yasin started his lesson with a question-and-answer session to unpack students' prior knowledge. He initiated the discussion by asking question and waited to hear the students' voices. In this period, the conversation included I-R-E, I-R-(RS (Restate)-I)-R, and I-R-RS-R at the beginning, Yasin's questions were for information seeking and he evaluated the answers. The reason for the evaluation may have been that students needed a base to construct their own knowledge of “sound”. I inferred that because, in Yasin’s classroom, “evaluation” was not a common teacher response and evaluated responses were in response to basic questions.

> Teacher: How do people or other creatures communicate each other? (I)
> Student 1: Teacher, by sound. (R)
> Teacher: They communicate with each other by sound. (E) So, while communicating, how do they make sound? According to you? How do they sound? (I) yes, Ibrahim?
> Student 2: Teacher, by vibration (R)
> Teacher: They make sound with vibration. (E) Another? (I)
> Student 3: By the vibration of vocal folds. (R)
> Teacher: By the vibration of vocal folds. So, while vocal folds are vibrating, (E) what can be a reason for this vibration? (I)

When you look at the conversation, the teacher evaluations seem like restating, but the teacher is accepting the responses and asking questions regarding them as a “right” answer; thus they become evaluation.

When the conversation continues and having a base to construct concepts about sound, the number of evaluations decrease and conversation patterns turn into I-R-RS-I-R or I-R-RS-R. For example;

> Teacher: … is there a difference between male and female sounds? (I)
> Students: yes (all together) (R)
> Teacher: C.
> C. : teacher, man sounds low-pitched; woman sounds high-pitched (R)
> Teacher: so you say man sounds low-pitched; woman sounds high-pitched (RS)
> C. : yes (R)

When Yasin did not evaluate and continued to initiate discussion based on their responses, students’ responses led the conversation. Yasin built the questions on students’ responses; therefore, the process continued in this pattern: I-R-I-R-I-R-…-E-RS-I-R. During this period, the teacher's first question was very broad: "how can people communicate with each other?" The answer is "sound" from students, and then the teacher narrowed down "sound" by questions to reach some more specific terms like "loudness", "frequency", "direction of sound," and "sound wave."

While the conversation was continuing, the students started to ask question. The teacher initiated a question, and then a student responded. As a result of wonder, another student asked a question of the respondent, and they had a short conversation. For example:

(While they were talking about how sound spreads or is transmitted, after a long conversation)

> Student 1: does sound transmit as linear? (I by student)
> Teacher: does sound transmit as linear? (RS)
> Students: no! (All together) (R)
> Student 2: Teacher, sound is transmitted as waves. We can hear a horn sound. (R)
> Students: yeah. (All together) (R)

During the first part, the question-and-answer session, these kinds of initiations by students were not common – just six times- but, in subsequent conversations, the talk between students increased.

<u>What the best question is / student to student talk within teacher talk</u>

At some point during question-and-answer session, the teacher summarized what students said and discussed and then he wanted them to develop their own questions about what they still wanted to know related to sound. This question would be their research question. Before generating questions, the teacher asked them the characteristic of a good question. The general response was a good question should be provable and testable. There should be a result to the experiment. According to these characteristic, they classified their questions.

While creating and classifying their research questions, the students had more involvement in developing their own questions. They had more discussions about the questions and how it should be classified, and the direction of the discussion was student to student. During this time, the teacher did not talk much, the student talk time increased, and the teacher role changed from the authority in the class to a participant in the conversations. When students criticized their friends' questions by asking the teacher, the teacher redirected them to the student who generated the question. For instance:

> S. : This question is a really good, but, in the testable perspective, how do you test and prove? (I by student)
> Teacher: She is asking to O. (direction)
> O. : When the pitch of the sound increase, speed of the sound increases. (R)
> S. : so, now, teacher, how can we see the sound waves? (I)
> Teacher: not me, ask H. (Direction)
> H. : we will look at the highness and lowness of the sounds pitch. (R)

The teacher's direction to ask each other encouraged student interaction. The teachers seemed to want to pull back himself from being authority and become a participant. We can infer that he was eager to support discussion where the direction was student to student. As a result, we heard more student voices and students initiated discussion six times during this period.

Experiments and teacher questioning as an observer

After each group selected a question to test, they started to do their experiment. While they were working, the teacher walked around and had some discussion with them to get informed about their process. These conversations included I-R-…-I-R patterns and at some points, the teacher restated what they said. The teacher did not take an evaluator role or give any directions. Even if they asked about their experimentation, he did not give orders or directions. While conducting their experiment, students were responsible for filling out the SWH templates. Each group composed a question, claims and evidence. After completing the experiment and filling out the SWH templates, in second class period, they presented their questions, claims and evidence and had a whole class discussion.

Teacher as a moderator / student to student interaction

The presentation and whole class discussion session included more student talk than the first class period. The teacher acted as a moderator. He asked them whether they had questions for the presenter group and reminded the presenting group to explain their claims and evidence if they forget. When we compared student talk and teacher talk in this part, teacher talk was very infrequent. During the presentation and whole class discussions, by the numbers, students initiated discussion thirty two times and evaluated each other ten times. The teacher intervened only once because a student was stuck in a subject. In that condition, the teacher intervened to clarify their claim by asking questions rather than giving orders or exact answers. He led them to do the experiment again with the student who objected to their results and claims.

Summary

In this chapter, the results of two phases of research were presented, the writing analysis and the video recording analysis. The video recording analysis was presented under four themes: teacher talk time, quantity and quality of questioning, lesson organization (purpose of class), and conversation patterns. The result show that each teacher had a different implementation of the SWH and their quality of questions were different and had different patterns. These findings will be discussed in the next chapter in detail.

CHAPTER V

DISCUSSION

In this chapter, research questions posed in the first chapter will be answered along with limitations and implications of the study and implications. Specifically, the research questions and results will be discussed by connecting results and literature. The limitations of the study will be addressed along with how they can be overcame. Finally, implications of the study for further research and for application in the classroom will be presented.

Answers to Research Questions

1. How are low and high level teachers', determined according to their students' writing scores, questioning patterns different from each other during classroom discourse?

The results show that the teacher whose students had high scores in writing samples asked more questions with the cognitive levels of these questions being higher than the low level teacher. The total talk time in two class periods of the teachers was almost equal, with the high level teacher talking slightly more. However, there is a great difference when looking at each class period. While the high level teacher talked more in first period, the low level teacher talked less, and for the second period, the situation was exactly the opposite.

The high level teacher had a more structured and organized classroom than low level teacher. The high level teacher structured the lesson at the beginning of the first period by asking more questions about the big idea, and then let the students to have opportunity to discuss the issue by themselves; afterward, he mostly intervened only when classroom management issues occurred in the second period. Thus, students became familiar with the topic and picked their question to test, and then they discussed their findings in the light of their prior discussion without any support by the teacher. As stated in previous chapters, students began by posing question, then did experiment to find answers to their questions. After the experiment, they had claims with evidence (Hand, 2008). The low level teacher did not have any structure at the beginning, but let the students do the experiment according to their understanding. In the second period, during the discussion section, he realized that students' understanding of the topic is not enough, and their experiments does not help them to get the big idea. Because of this, he got involved more in the discussion section. Moreover, he used some traditional teaching method and answer their questions by the words "right"-"wrong" or acting as an authority. There is a similar pattern between their talk turns and question numbers for first and second periods; in contrast, high level teacher has more talk turns and question numbers in comparison of total. According to Aguiar, et al (2010) if the teacher leaves students on their own, the student are not willing to ask more questions of each other (Chin & Osborne, 2008). Consequently, the activity of high level teacher can support students' activity and engage students in the big idea. The activity of high level teacher triggered students to ask questions each other and this will be explained above.

After examining the quantity of the teachers' talk, the quality of the teachers' talk is examined to see the difference between these teachers' questioning pattern. The Bloom's taxonomy is used to describe the cognitive level of teachers' question. The high level teacher asked more questions than low level. These questions included knowledge, comprehension and analysis level questions. Moreover, the high level teacher asked more questions for each level in terms of numbers and percentages. These findings show parallel results with the findings of Gunel, et al (2012): If the teacher ask high level cognitive questions, the students tend to begin a negotiation as whole class or group, or vice versa. In our study, if the teacher ask high level questions, students tend to have high level individual negotiation which can be transferred to their science writing. Moreover, Cimer (2007) emphasized the importance of high level cognitive questions by stating that high level cognitive questions provide students an opportunity to make connections between their prior knowledge and new knowledge. So this high level cognitive questions can help students make connections for their practices like writing.

As a next step to understand teacher's question pattern, their conversation patterns can provide more detailed information. The low level teacher posed question without waiting for any response from the students and just strolled between groups at the beginning. So, there was no conversation initiation between students and teacher, or among students. On the contrary, the high level teacher waited for the response from students, and after their responses, he did not tend to evaluate their response but posed one more question to unpack their prior knowledge. Moreover, he let the students evaluate each other's response. The dominant characteristic of the low level teacher's conversation was classic I-R-E although he tried to implement some follow-up patterns like I-R-I-R…I-R. On the other hand, the high level teacher generally adhered to a conversation pattern with follow-up rather than I-R-E pattern. While the low level teacher was taking a position as an authority, the high level teacher acted as a moderator and let the students interact with each other. Especially in the last part, presentation and discussion session, the high level teacher seemed to want to pull back from being an authority and his response were more neutral rather than evaluative (van Zee & Minstrell, 1997b; Chin, 2007). He let his students initiate (asking questions), respond to each other's questions, and evaluate the answers by themselves. He supported the student-student interaction. The high level teacher's attitude can be explained by van Zee, et al.'s (2001) findings; if the teacher asks questions to get answers at the knowledge stage, the number of students' questions decreases. So we can infer that he asked more various questions in different cognitive level; therefore, his students' question numbers were high (Gunel, et al, 2012). Moreover, the high level teacher had a role as a participant to learn something from his students.

2. Is there a relationship between students' writings and teachers' questioning style in the classroom?

The main goal of this question was to examine the students' pattern about negation which they learn in a classroom environment as a social act and how they can apply their learning in classroom to a new situation such as an individual activity through writing (Hand, 2008). In the writing activity, students apply not only content but also scientific thinking process like negotiation. Thus, if the students do better comparing and contrasting in their writing activity, I would suggest that they learned it in their classroom activity. The main difference between high and low scored classrooms is the teacher. In this study, we examined teachers' activities and talks. By comparing the low and high teachers, determined by their students' writing scores, I found big differences as presented in the answer to the first research question. I believe that the students transferred what they learned in the classroom, both scientific content and process, into their writings which is strongly related to negotiation because they are making comparison between their findings from experiments and various sources. The comparison is an individual activity which requires high level cognition.

Teachers' classroom implementations show big differences based on argumentation patterns. For example, the high level teacher frequently asked question at the beginning of the first period, which was an introduction to big idea. To ensure that the students stayed topic, the teacher questions got their attention; and then, they started asking their own questioning about the big idea. Also the teacher did not tend to give feedback as "right" or "wrong". This is the characteristic of inquiry based teaching (Baird & Northfield, 1992). He let the students ask their own questions which they were going to test. He gave more freedom to his students about their questions and experiments in the selection period. Therefore, the students easily got engaged with big idea, and this engagement supported students' negotiation at both the individual and social level. So, the teacher's implementation of argument based inquiry approach is in a high level. That affects students' engagement with argumentation and implicitly this argumentation can affect quality of students writing. Moreover, questions promote an argumentative environment and improve critical thinking skills through discussing different ideas and claims (Gunel, Kingir, & Geban, 2012, Chin & Osborne, 2008, Cavegnetto, 2010, Duschl, et al. 2007; Berland & McNeill, 2010). In a better argument-based inquiry implementation, students were exposed to more question from the teacher and other students, therefore their critical thinking skills were getting stronger. These critical thinking skills will be transferred to another situation. In this study context, students would appear to have transferred their learnings in the classroom about argument process to their writing activity. There is a great difference in classroom implementation between high and low level teachers. This difference can explain why their students writing scores were different. As a result, the researcher believe that there is a relationship between classroom implantations and students' writings but these still need more detailed studies on this relationship.

Limitations

The researcher recognizes four areas of limitations. Firstly, the video recordings are done by the research project team and the researcher of this study did not have a chance to select time or topic for each teacher. The writing samples belong to teachers and video recordings were collected a year after writing samples were collected. In this period, the teachers' implementation level of SWH approach would have increased because their professional development sessions continued. The same limitations exist in the writing samples. If the writing samples and video recordings came from same year and same students, the results can give more appropriate results.

Secondly, the small sample size is another limitation. In this study, the researcher focused on just two teachers and their two class periods. The small sample size requires more qualitative analysis in different perspectives for each teacher, but it limits any sense of generalizability that might result from analysis. Employing more class periods for each teacher and more teachers for each level can provide richer evidence for the findings of this type of studies.

Thirdly, the training sessions to score students writing samples is done with English samples but the writing samples for this is study are in Turkish. Although the main frame is similar, the difference in language structure between Turkish and English may cause some inaccuracy. For future studies, researcher need to be trained in the language in which the writing samples were. As part of the training session, they can create a rubric based on samples which includes similar sentence structures and students responses.

Finally, the coding for teacher talk according to Bloom's taxonomy was firstly done by the researcher, and then another coding was done by another coder after training. Although they had a high agreement on coding, the researcher would suggest that firstly, the people who are going to code should work together to agree on coding rubric and then the researcher should complete coding. In relation to this issue, the general limitation for this study is that this research is the first study of the researcher. As such, there should be some subtleties of the research that need further development because of the researcher's lack of familiarity with the research process.

Implications

The comparison of high and low level teachers' implementations shows that the inquiry teaching does not mean that the teacher talk less. The high level teacher, who has good implementation of argument-based inquiry in his classroom, talks more but the place, in which this talk occurred, differed. So the teachers who are willing to apply argument-based inquiry in their classrooms can use the pattern of high level teachers where there is more talk at the beginning of the topic, after that, there is a need to pull back, and let students initiate and discuss with each other. To increase students' participation and questioning, teachers should focus on asking high level cognitive questions. If there is no teacher's effort at the beginning, they need to perform more at the end of the class, but this final effort may not help students to learn in argument settings, and the teaching method would be more traditional, than what is required for argument-based inquiry.

The results of this study suggest further research on a comparison study by examining teachers and their students' argumentation pattern by comparing students writing samples within a same unit in an argument-based inquiry. This can provide more practical results to see how the students' writings are shaped by classroom implementations and discussion patterns. Examining students' argument pattern and comparing them with negotiation pattern in their writing samples may provide a clearer picture about how their argumentation is developed. Another research suggestion is that we can look at the students' lenses to understand how students understanding is shaped by classroom and writing activities. For this aim, some students could be selected and their classroom's argumentation environment and their writing be examined. Beside these examinations, a number of interviews can be conducted after each activity to uncover what they are thinking while they are doing these activities. This kind of research can be more powerful to explain the transfer of negotiation skills from social level to individual level.

❖ This thesis was supported by a project funded by Scientific and Technological Research Council of Turkey (TUBITAK). The grand number is 109K539.

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