SCIENCE TEACHERS’ THEORY AND PEDAGOGY OF ARGUMENTATION IN SCIENCE EDUCATION: DESIGN, IMPLEMENTATION, AND EVALUATION OF A GRADUATE COURSE THROUGH EDUCATIONAL DESIGN RESEARCH

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ABSTRACT

SCIENCE TEACHERS' THEORY AND PEDAGOGY OF ARGUMENTATION IN SCIENCE EDUCATION: DESIGN, IMPLEMENTATION, AND EVALUATION OF A GRADUATE COURSE THROUGH EDUCATIONAL DESIGN RESEARCH

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The current study is an educational design research on the design, implementation and evaluation of a graduate course that is aimed at improving science teachers' theory and pedagogy of argumentation in science education. It was aimed to describe the educational design process of a graduate course with a reflexive approach. In addition to the design process, the science teachers' instructional practices in argumentation based lessons were explored in the study.

The participants were 1 elementary school science teacher, 2 high school science teachers and 4 graduate students, who were all pursuing a graduate degree in science education.

The study comprised two parts: The first part reported the design, implementation and evaluation of a graduate course, named as "Argumentation in Science Teaching and Learning". Educational design research methodology was applied to achieve the professional development of science teachers. The audio-recorded course sessions, post-interviews, and participants' written materials were constituted the data. The results revealed the elements of an effective design solution. Moreover, the results demonstrated that the design solution contributed to the participants' understanding of argumentation, and all participants had meta-level knowledge of argumentation in science education.

The second part was the exploration of the participants' instructional strategies on argumentation based lessons. Data sources included the participants' video-recorded classroom practices, audio-recorded reflections, post-interviews, and participants' written materials. The findings revealed six typology named as argumentation specific pedagogical knowledge, meta level pedagogical knowledge specific to argumentation, general pedagogical knowledge, meta level general pedagogical knowledge, meta-strategic knowledge, and meta-strategic knowledge specific to argumentation.

Keywords: Educational Design Research, Argumentation, Instructional Strategies, Science Teacher Education, Auto-ethnography

ÖZ

FEN BİLİMLERİ ÖĞRETMENLERİNİN, FEN EĞİTİMİNDE ARGÜMANTASYONA İLİŞKİN KURAM VE PEDAGOJİLERİ: BİR YÜKSEKÖĞRETİM DERSİNİN EĞİTİM TASARIM ARAŞTIRMASI İLE TASARIMI, UYGULAMASI VE DEĞERLENDİRİLMESİ

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Bu çalışma, fen bilimleri öğretmenlerinin fen eğitiminde argümantasyona ilişkin kuram ve pedagojilerinin geliştirilmesini hedefleyen bir yükseköğretim dersinin tasarım, uygulama ve değerlendirilmesine yönelik eğitim tasarımı araştırmasıdır. Çalışmada dersin eğitim tasarımı olarak geliştirilmesi öze dönüşlü yaklaşımla betimlenmiştir. Ayrıca çalışmada fen bilimleri öğretmenlerinin argümantasyona dayalı derslerinde uyguladıkları öğretim stratejileri araştırılmıştır.

Çalışmada fen bilimleri alanında yükseköğretim yapan 1 ortaokul fen bilgisi öğretmeni, 2 lise kimya öğretmeni ve 4 yükseköğretim öğrencisi yer almıştır.

Çalışma iki bölümden oluşmaktadır: Birinci bölüm "Fen Öğretiminde ve Öğreniminde Argümantasyon" başlıklı yükseköğretim dersinin tasarım, uygulama ve değerlendirilmesini betimlemektedir. Bu bölümde öğretmenlerin mesleki gelişimlerine katkıda bulunmak amacıyla bir eğitim tasarım araştırması yürütülmüştür. Ders ses kayıtları, son görüşmeler ve katılımcı öğretmenlerin yazılı çalışmaları veri kaynaklarını oluşturmaktadır. Bulgular etkili bir eğitim tasarımı içeriğini ortaya koymaktadır. Ayrıca bulgular, bu tasarım içeriğinin öğretmenlerin argümantasyona ilişkin anlayışlarına katkıda bulunduğunu ve öğretmenlerin fen eğitimnde argümantasyona ilişkin üst düzey bilgi sahibi olduklarını göstermektedir.

İkinci bölüm, katılımcı öğretmenlerin argümantasyona dayalı derslerinde uyguladıkları öğretim stratejilerinin araştırılmasıdır. Bu araştırmada, öğretmenlerin ders görüntü kayıtları, kendi uygulamalarına ilişkin yansıtıcı konuşma ses kayıtları, son görüşmeler ve öğretmenlerin yazılı çalışmaları veri kaynağı olarak kullanılmıştır. Bulgular, öğretim stratejilerini altı üst kategoride toplayarak yorumlanmıştır: argümantasyona yönelik pedagojik bilgi, argümantasyona yönelik üst düzey pedagojik bilgi, genel pedagojik bilgi, genel üst düzey pedagojik bilgi, üst bilişsel stratejik bilgi ve argümantasyona yönelik üst bilişsel stratejik bilgi.

Anahtar kelimeler: Eğitim Tasarımı Araştırması, Argümantasyon, Öğretim Stratejileri, Fen Bilgisi Öğretmen Eğitimi, Otoetnografi

To Hüseyin Oğuz Yılmaz,

my wonderful husband, for his endless patience

and love.

This was only possible with you.

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EDR	:	Educational Design Research
ASPK	:	Argumentation Specific Pedagogical Knowledge
ML-ASPK	:	Meta Level Pedagogical Knowledge Specific to Argumentation
GPK	:	General Pedagogical Knowledge
ML-GPK	:	Meta Level General Pedagogical Knowledge
MSK	:	Meta-Strategic Knowledge
MSK-A	:	Meta-Strategic Knowledge Specific To Argumentation

CHAPTER 1

INTRODUCTION AND PHILOSOPHICAL ASSUMPTIONS

Argumentation can be described as a kind of discourse through which knowledge claims are individually and collaboratively constructed and evaluated in the light of the empirical or theoretical evidence, alternative views, justifications and rebuttals (Jiménez-Aleixandre & Erduran, 2008; Kuhn, 1993). It has a central place in many of the endeavours carried out in science, such as developing simplifications, establishing cause-effect relationships, and in presenting evidence from observation and experiments (Newton, Driver, & Osborne, 1999; Osborne, 2010). From this perspective, it is an essential component of decision making, in which scientific and technological knowledge comes into play (Patronis, Potari, & Spiliotopoulou, 1999). It is also vital in data analysis, manuscripts with persuasive explanations, and dialogues (Clark & Sampson, 2007).

Argumentation has also been a prominent concern in science education research, and a common goal in science curriculum in many countries over the past decade (Lee, Wu, & Tsai, 2009; Ozdem, Erduran, & Park, 2011; Science Teacher Education Advanced Methods [S-TEAM], 2010). For instance, in an analysis of research trends in science education from 2003 to 2007, Lee, Wu, and Tsai (2009) found that four of the ten most highly cited papers from 1998 to 2002 included the word argumentation in their title, and between 2003 and 2007, five of the 10 most highly cited papers included either the word argumentation or informal reasoning in their title. Similarly, an extended review of argumentation analysis by Ozdem, Erduran, and Park (2011), covering the time period of 2003-2009, revealed that 62% of articles in top three education journals are related to broad range of argumentation research.

The recent reform documents (Ministry of National Education in Turkey [MNE], 2013; National Research Council [NRC], 2012) also call for students to practice argumentation in science classrooms especially in elementary grades (McNeill, Gonzalez-Howard, Katsh-Singer, & Loper, 2014), mainly because student engagement in scientific argumentation can enhance their understanding of the concepts and the processes of science (Sampson & Blanchard, 2012). For example, the Science Curriculum in Turkey, which has been in use since 2013, incorporates crucial changes about argumentation. The term argumentation was used explicitly in this curriculum and the teachers were encouraged to employ argumentation as a teaching strategy in the teaching of science in elementary grades. Students are expected to construct strong arguments based on sound justification regarding natural and physical environment. Teachers are responsible to involve students in dialogues, which incorporate students' varied justifications in support of their claims and construction of counter-arguments to refute the oppositions. Moreover, teachers are expected to be guides in students' spoken or written argumentation by encouraging them to present their claims based on valid data and sound justifications (MNE, 2013, p. III).

Therefore, it is important to acknowledge and inform teachers about argumentation and assist them in improving their theory and pedagogy of argumentation so that they would be able to meet the expectations that the research and curriculum bury on them. On the other hand, when the expectations investigated deeper, it is really vague what the teachers should be able to do to integrate argumentation in their classrooms. For example, the research and the curriculum say little about what teachers really need to know about argumentation and which instructional strategies result with argumentation in science classes.

In this study, my main purpose was to develop an educational design to contribute to the solution of this problem. The aim of the design was to construct and mature a course aimed at improving science teachers' knowledge and pedagogy related to argumentation so that they could be able to incorporate argumentation into their teaching. My purpose was threefold; one is to study with the science teachers in the design of a learning trajectory that supports them become educated and conscious about bringing argumentation practices into their classes; second, to trace their development in learning to teach argumentation, and last, to explore the instructional strategies that they employed in implementing argumentation-based strategies in their science lessons.

In the following, in this chapter, I clarified the problem statement based on the related literature to legitimize my abovementioned purpose; I provided my personal motivation for this study and stated my research questions afterwards. The chapter continued with the significance of this study. At the end of this chapter, my philosophy of education in general and science learning in specific, which is the social constructivist view of learning, were made explicit in order to help myself and other readers engage in an argumentation about my arguments and my perspective in this study in the context of argumentation research as well as individual and social development.

1.1. The Problem Statement

The interest in argumentation is mainly due to the research maintaining that argumentation is a key element of the “scientific culture” and an indispensable part of the science education in schools (Jiménez-Aleixandre & Erduran, 2008; Tiberghien, 2008). Research suggest the teaching of argumentation in schools as part of the learning of scientific inquiry and scientific literacy (Duschl & Osborne, 2002; Erduran, Simon, & Osborne, 2004; Jiménez-Aleixandre, Rodriguez, & Duschl, 2000; Zohar & Nemet, 2002), helping to promote students’ scientific reasoning and conceptual understandings (Lawson, 2010; Yeşiloğlu, 2007; Zhou, 2010) as well as supporting students enculturation into the practices of scientific culture (Dawson & Venville, 2010; Jiménez-Aleixandre & Erduran, 2008).

However, the presence of argumentation in the policy documents does not ensure its implementation (S-TEAM, 2010). It is clear that efforts at the level of science curriculum are not enough to accomplish the systemic application of argumentation in science classrooms (Jiménez-Aleixandre & Erduran, 2008).The research studies point to the lack of opportunity given by teachers for students to discuss alternative views in groups, or to interpret events, experiments, or social issues as a class (Driver, Newton, & Osborne, 2000). A significant problem about argumentation in science classrooms rises to be teachers’ lack of pedagogical knowledge necessary to design argumentation-based lessons or the lack of resources to assist them skills to mediate the learning environment in argumentation based science lessons (Duschl, 2008; Erduran, Simon, & Osborne, 2004). These causes argumentation considered as a challenging practice for many science teachers since they must not only go beyond adopting the curriculum or understanding the requirements of educational reforms, but also must know the argumentation strategies and be proficient in carrying-out evidence-based argumentative activities (Zembal-Saul, 2009; Zohar, 2008). On the contrary, the research indicates that teachers are either not familiar to such an approach aligned with constructivist and inquiry-based teaching approaches (Jiménez-Aleixandre, 2008) or not comfortable since teaching argumentation requires a fundamental shift in the pedagogies that they already use (Simon, Erduran, & Osborne, 2006; Zohar, 2008).

The professional development of teachers, therefore, in argumentation is important. Particularly for the less successful groups, research suggests that improvement in students’ ability to engage in argumentation could be achieved through teachers’ ability to guide groups in debates (Driver, Newton, & Osborne, 2000). Moreover, educational requirements that come with integration of argumentation can be reflected in the methods and instruments that support the learning and teaching process, including the design methods and tools. Therefore, in professional development programs for argumentation, teachers are introduced to argumentation as well as a range of different kinds of argumentation activities and pedagogical strategies; encouraged to develop their pedagogic practice with argument, and they are asked to incorporate argument-based lessons (Simon, Erduran, & Osborne, 2006; Simon & Johnson, 2008; Simon, Richardson, Howell-Richardson, Christodolou, & Osborne, 2010; Tiberghien, Vince, Coince, & Malkoun, 2011; Tümay, 2008). Consistent with this effort, the researchers developed a number of instructional activities and professional development frameworks aimed at introducing scientific argumentation in the science classrooms for pre- and in-service science teachers (Walker & Sampson, 2013; Zohar, 2008).

These programs and frameworks provide valuable information regarding what teachers need to know in order to be able to integrate argumentation proficiently in their science classrooms. However, the main question about these programs pertains to the fact that teaching argumentation requires a fundamental shift in the pedagogies that teachers use. The teachers must be provided with adequate pedagogical knowledge in the context of teaching argumentation, above and beyond the sound knowledge of argumentation strategies (Zohar, 2008). Moreover, these programs aimed at developing teachers' teaching argumentation-based science lessons must also centre on other fundamental issues that pertain to pedagogy of knowledge construction, such as the instructional theories that the teachers are committed to, in addition to addressing elements of teaching argumentation (Zohar, 2008). For this reason, teacher education programs and professional development programs must be of a considerable duration, which is usually not feasible because of either financial or contextual resources. Osborne et al. (2011) indicated that substantial resources are spent each year by all countries on professional development, despite the thin evidence base for their effectiveness.

Alternatively, Avraamidou and Zembal-Saul (2005) pointed to the specific university coursework and the elementary science methods course in reconstructing teacher pedagogy and facilitating conceptual change. Such courses may also address the need to trace the developmental stages in the learning to teach argumentation, and help to construct the learning trajectories for science teachers in learning how to teach argumentation (Erduran, 2006; Erduran, Ardac, & Yakmaci-Guzel, 2006; Simon, Erduran, & Osborne, 2006). However, Walker and Sampson (2013) indicated that scientific argumentation is not emphasized in most undergraduate and graduate science courses, and it has not been a prominent type of discourse among college science educators.

Building on the above mentioned necessity, therefore, in this study, I designed a graduate course, which is aimed at improving science teachers' and graduate students' knowledge and pedagogy related to argumentation so that they could be able to incorporate argumentation into their teaching.

1.2. My Motivation for the Study

I had been a science teacher for five years and have been a researcher in science teacher education program for another five years. During my career as a teacher and researcher, I was expected to teach science concepts through inquiry-based methods, which enable students to engage in critical thinking about the scientific concepts and methods of science in collaboration with others. In the inquiry-based lessons, which usually took place in the science laboratory, I always enjoyed the process of discovery and the critical discussion we held with the students and the pre-service science teachers. There was a data collection and evaluation process that was rather systematically proceeds, but from my perspective what made the learning most accessible was the discussions. However, I never felt satisfied with the lab reports ending with the sentence “our hypothesis was supported/ rejected”. On the other hand, I did not know what to expect as a response to my question “why?” because the answer was already there as data and that- I thought- was enough to say the hypothesis was supported or rejected.

While this disconnectedness in my mind, I was also in search of a topic for my masters’ thesis. In my attempts to find a solution for this “problem” in the literature, I realized that the missing chain was the “evidence”, and evidence could take other forms in addition to experimental data. This was my first encounter with argumentation during my research about evidence. Reading more about argumentation, I was convinced that as a discussant type of person, this practice was what I was looking for and worth trial in laboratory. I identified the topic of my master’s thesis as argumentation, and designed and implemented argumentation-based laboratory sessions with pre-service science teachers. The participants expressed their appreciation and enjoyment as much as I did.

I think that argumentation is- surely not the only one but one of- a promising theory to be considered in education in general, and specifically in science education. I enjoy being part of argumentation and still believe that argumentation has wider implications for the society. Nevertheless, it was difficult to disseminate results in the form of practical applications. There was no possibility to conduct a follow-up study to observe the pre-service teachers in their in-service years. Moreover, I did not give any instruction about argumentation to the pre-service teachers that I studied with.

Thus, I decided to continue my research on argumentation by being involved in or designing a project to work with in-service teachers so that I could access to a wider community and observe how the laboratory trials work in real life contexts. This study was a result of this endeavour.

1.3. Research Objectives and Questions

The research questions that guided this study were;

1. How does a graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning contribute to in-service science teachers' knowledge related to argumentation?
    a. What are the elements of a graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning?
    b. How do science teachers' understanding of argumentation change over the graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning?
2. What are the instructional strategies science teachers and future teacher educators make use of in the planning and classroom practices to implement argumentation over the graduate course?
    a. Does a cycle of reflective practice, based on the use of argumentation, enable science teachers to implement instructional strategies to promote argumentation in their teaching practice?
3. How were the theory and practice gaps revealed with regard to argumentation in science education?
    a. How was the science teachers' theory-practice gap revealed in the experiences of the science teachers enrolled in the graduate course?
    b. How does science teachers' understanding of pedagogy of argumentation change over the graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning?

In addition, I also focused on myself as a researcher and a facilitator due to my understanding of the research. According to the constructive interpretive research paradigm, which is elaborated in the following chapter (Chapter 2, p.19), at the epistemological level, the meaning and the knowledge is actively and collaboratively co-constructed by the researcher and the respondents (Denzin & Lincoln, 2005). Therefore, the researcher cannot objectively mirror or measure the data like an outside observer. On the contrary, the researcher is thought to be a research instrument as well because the researcher’s personality and approach to research characterizes the study. Hence, I further investigated the following research questions in this study;

4. What were my experiences in the graduate course as a researcher and a facilitator designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching?
5. How was the theory-practice gap revealed in my experiences as the facilitator in the graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning?

To investigate the given research questions, I designed a graduate course based on the successful models of teacher professional development programs and in multi-cycles so that the course content and implementation foster the participants’ abilities to teach science in a way that would develop students’ autonomous argumentation in scientific issues. The research design of such a graduate course was carried out by a methodology, through which theories of learning inform the design of educational interventions and are informed by the implementation of these designs (Kelly, Lesh, & Baek, 2008; Majgaard, Misfeldt, & Nielsen, 2011). The methodology called educational design research (EDR) was utilized in this study to develop the theoretical and pedagogical understanding of teachers in regard to argumentation as well as to contribute to the argumentation theory in science education.

1.4. Significance of the Study

Answering the research questions stated above will provide us with theoretical insights and practical contribution to the solution of the abovementioned problem situation.

In terms of theoretical insights, the significance of the study is its contribution to understanding how science teachers’ knowledge of argumentation was translated into classroom practices. The educational design that was aimed to be developed in this study provided the science teachers with meta-level knowledge about argumentation through a research based cycle of intervention. However, we have little understanding of how teachers transfer their knowledge and understanding about scientific argumentation or of the extent to which they are able to enact the strategies they have learned in professional development opportunities in the teaching and learning of science. Therefore, this study is significant in the way it addressed this issue.

Another significance of the study is its help to understand how teachers perceive their practices. The research evidence shows that teachers’ knowledge and views about argumentation and its practice in science education are crucial to the enactment of argumentation components in the curriculum, integration of argumentation as an instructional approach, or designing learning environments that foster argumentation (Sampson & Blanchard, 2012). That is because any reform efforts are often shaped by teachers in the classroom (Blanchard, Southerland, & Granger, 2009; Haney, Lumpe, Czerniak, & Egan, 2002). Therefore, this study contributes to understanding the teachers' perspective in integrating argumentation in terms of the struggles they experienced their views about the theory-practice compatibility, and the value they attributed to the argumentation in science education.

In terms of practical contribution, the study is significant in providing a design solution in response to the problem by means of the development of a course. The course was developed and refined to be a solution to the problem of teachers' lack of knowledge and pedagogy in relation to argumentation in real practice. Moreover, it was the resulting product of the intervention, which was empirically tested and refined. Therefore, another significance of the course developed in this study is that it addressed the need for a well-designed professional development program, which provides an advanced level of argumentation knowledge and pedagogy in teacher education.

The last chapter of this study, which is the auto-ethnographic account of my experiences as a researcher and a facilitator, has significance mainly because of its methodology and analytic structure. The auto-ethnography provided a broad description of the social world under study from the perspective of the facilitator and the researcher, which is very rare in research on professional development and specifically the one on argumentation.

In terms of analytic structure, the auto ethnography in this study provided a record of the connections between my theoretical commitments and social structure in the course that I was involved in to design and evaluate. In this regard, the study is significant in providing the researchers an opportunity to explore the analytic perspective in terms of the interplay between a researchers' self-knowledge and the sociocultural context.

These significances of the study were explicated further in the subsequent chapters. In the following, the introduction chapter continues with the educational philosophy that framed this study.

1.5. The Philosophy of Education

The philosophy of education is described as "a comprehensive and consistent set of beliefs about the teaching-learning transaction" (Conti, 2007, p. 20). The purpose of making the educational philosophy explicit is to help "educators recognize the need to think clearly about what they are doing and to see what they are doing in the larger context of individual and social development" (Ozmon & Craver, 1981, p. x). The ontological and epistemological aspects of philosophy concern with the educator's worldview that shape the perceived relative importance of the aspects of reality, such as the nature of reality, what can be known about it, and the nature of the relationship between the knower and knowledge (Thomas, 2010). Thus, in this section, I clarified my approach towards the teaching and learning of argumentation in science education.

There are different orientations that are linked to argumentation in science learning. For example, van Eemeren and Grootendorst (1988) approached argumentation from pragma-dialectic approach, which assumes a consensualistic theory of argumentation. Lumer (2008) explains the function of argumentation in this theory as "the elimination or resolution of a difference of opinion" (p.41). Sampson (2007), on the other hand, stated that when argumentation is considered as a practice that is used for problem solving and advancing knowledge by an individual or a social group, it aligns well with situative theories of learning. Beyond all, as Hofstein, Kipnis and Kind (2008) stated, one reason that has brought argumentation to be one major goal in science education is its link to social constructivist view of learning, which is mainly based on the works by Vygotsky. In this study, I also constructed my arguments based on social constructivist views of learning in science education. In the following section, constructivism, social constructivist learning theory and its relation to argumentation as well as this study are explained.

1.5.1. Constructivism in Education

Constructivism has been raised in the beginning of 1960s by Bruner and has been a concern throughout the 20^{th} century especially in the fields of development psychology and cognitive psychology. It has also been used as a major concept in the educational studies, which focus on learning and teaching processes (Arslan, 2007; Young & Collin, 2004).

Şimşek (2004) stated that "constructivism involves a wide array of –ism, ranging from the representationism, which asserts that the mind perceives only mental images (representations) of material objects outside the mind, but not the objects themselves *(Encyclopaedia Britannica; representationism)*, to solipsism, which holds that knowledge of anything outside one's own mind is unsure *(Wikipedia; solipsism)*" (authors' translation) (p. 117). Similarly, a taxonomy of various forms of constructivism exists based on the answers to who constructs, what the constructed is, out of why and how it is constructed (Irzık, 2001).

According to Young and Collin (2004), constructivism is a perspective in developmental and cognitive psychology and it was mainly shaped by Bruner, Kelly, Piaget, von

Glaserfeld, and Vygotsky. Yurdakul (2004) indicated that constructivist learning theory has its roots in the works by Piaget and Vygotsky, yet Dewey is also a central figure in the development of the theory. Ergün and Özsüer (2006) indicated that Vygotsky's approach in learning and education including his disagreement with Piaget's theory has important implications for teaching and learning. Arslan (2007) argued that constructivism is a supposition, which has been worked by many philosophers and educators; however, foremost Jean Piaget and John Dewey influenced the educators.

In education, constructivism can be characterized in three areas; epistemology, pedagogy, and psychology (Ünder, 2010).

Constructivism as an epistemological approach offers assumptions and evidence regarding the nature of the relationship between the knower and knowledge, such as subject-object relationship, knowledge, reality, scientific theories, scientific methods, and the role of observation; and positions the knower at the centre of all relationships in the construction of cognitive structures (Ünder, 2010).

In his writing on objectivist and constructivist debate, Wilson (1993) considered constructivism is more a philosophy or a way of seeing the world. He further claimed that this way of seeing the world includes notions about

- "The nature of reality, which holds that mental representations have the same "real" ontological status just as the "world out there" does
- The nature of knowledge, which is individually constructed inside people's minds, not "out there"
- The nature of human interaction, which assumes that we rely on shared or "negotiated" meanings, better thought of as cooperative than authoritative or manipulative in nature, and
- The nature of science as a meaning-making activity with the biases and filters accompanying any human activity" (p. 1135).

In a similar vein, according to Savery and Duffy (2001), constructivism is a philosophical view on how individuals come to understand or know and has three primary propositions: "(1) Understanding is in our interactions with the environment, (2) cognitive conflict or puzzlement is the stimulus for learning and determines the organization and nature of what is learned, and (3) knowledge evolves through social negotiation and through the evaluation of the viability of individual understandings" (pp.1-2).

Here "to know" has a different meaning from realist perspectives, according to von Glasersfeld (2000), who are the pioneer of radical constructivist view: "Although Piaget said dozens of times that, in his theory, “to know” does not mean to construct a picture of the real world, most of his interpreters still cling to the notion that our knowledge must somehow correspond to a world thought to be independent of the knower… Radical constructivism does suggest such a substitute. It holds that knowledge is under all circumstances constructed by individual thinkers as an adaptation to their subjective experience.” (p. 234)

In other words, according to the epistemological approach to constructivism, knowledge is a human construction. The natural world, which exists and impinges on thoughts and actions of the knower, can only be known through the knower’s’ construction of the knowledge regarding this world (Driver, Newton, & Osborne, 2000).

Constructivism as a pedagogy can be described as practical suggestions for teachers to engage students in the construction of meaningful and permanent knowledge. The practices such as promoting students’ active participation, paying attention to their prior knowledge regarding a topic, diagnostic teaching to deal with the misconceptions or alternative conceptions of the students, and giving importance to meaningful learning and reasoning are examples of constructivist pedagogy (Ünder, 2010).

However, there are *criticisms directed towards* constructivism regarding *the pedagogical implications* of it. The critics of constructivism as pedagogy emphasize that the strategies brought with constructivist approaches, such as active learning and critical thinking are not new to education (Airasian & Walsh, 1997, Irzık, 2001; Matthews, 2002). For example, Matthews (2002) stated that;

> “Constructivism has done a service to science and mathematics education: by alerting teachers to the function of prior learning and extant concepts in the process of learning new material, by stressing the importance of understanding as a goal of science instruction, by fostering pupil engagement in lessons, and other such progressive matters. But liberal educationalists can rightly say that these are pedagogical commonplaces, the recognition of which goes back at least to Socrates.” (p. 132)

On the other hand, Tobin and Tippins (1993) noted that this view of constructivism in science education means to “reduce constructivism to a set of methods and diminishes its power as a set of intellectual referents for making decisions in relation to actions.” (p.7) Indeed, constructivism in education help us to explain the students’ meaning making through their experiences, in interactive discussions or in small group problem solving activities (Tobin & Tippins, 1993). In other words, constructivism as a learning theory can be used to understand the ways learning occurs and contribute to the improvement of the quality of learning (Tobin & Tippins, 1993).

Constructivism as a learning theory is a psychological approach. The learning theories by Piaget and Vygotsky are examples of constructivism as a psychological approach. In general, these theories explain how conceptual schemes are constructed in students' mind and how students learn or construct knowledge (Ünder, 2010). This perspective basically assumes that knowledge cannot be transferred from the teacher to the student but is actively constructed by the learner (Driver, Asoko, Leach, Mortimer, & Scott, 1994, Walker & Sampson, 2013).

Rovai (2004), for example, described constructivism as a philosophy of learning, which acknowledges that knowledge is constructed by the individual through interactions with his or her environment. The main argument is that individuals gradually construct an understanding of their world through experience, maturation, and interaction with the environment and all other elements of the environment, including other individuals by actively processing information (p.80).

However, although there is an agreement among constructivists on the idea that knowledge is a human construction, there are different approaches to the constructs such as knowledge, reality, and learning within constructivism. Therefore, there are different constructivist approaches to learning that can be grouped as cognitive and developmental approach based on the works by Piaget, social constructive approach stemmed from the works by Bruner and Vygotsky with an emphasis on interaction and culture, and von Glasersfeld's radical constructivism based again on the works by Piaget and biological sense of evolution.

Cognitive constructivism has its roots in cognitive learning psychology and in the works by cognitive learning psychologist Jean Piaget. The main argument of cognitive constructivism is that children construct their own knowledge as they interact with the world around them. "These interactions enable students to create schemas or mental models; the models are changed, enlarged, and made more complex as children continue to learn. Direct, repeated experience is the key for assimilating new information into the child's existing mental constructs. If the experience itself is different or new, the child will accommodate or modify his or her existing constructs to reach cognitive stability or equilibrium" (Steiner, 2014, pp. 319-320)

Social constructivism, by contrast, critics the ignorance of the cognitive theory to the elements of social context, and has an argument that learning and development are social and collaborative activities. As the founder of this theory, Lev Vygotsky suggested a social cognition learning model, which emphasizes the role of the teacher and the learning context for both cognitive development and learning. "…'zone of proximal development' as the primary vehicle for learning. This zone is the developmental space between those tasks children can accomplish on their own with no help (or those they already know) and those they cannot perform even with help from others." (Steiner, 2014, pp. 319-320)

Radical constructivism is described by von Glasersfeld as being similar to evolutionary theory; "…the basic principle of radical constructivist epistemology coincides with that of the theory of evolution: Just a the environment places constraints on the living organism (biological structures) and eliminates all variants that in some way transgress the limits within which they are possible or "viable," so the experiential world, be it that of everyday life or of the laboratory, constitutes the testing ground for our ideas (cognitive structures)." (von Glasersfeld, 1984, p. 20). Thus, according to radical constructivist theory "The function of cognition is adaptive, in the biological sense of the term, tending towards fit or viability"; and "Cognition serves the subject's organization of the experiential world, not the discovery of an objective ontological reality" (von Glasersfeld, 1995, p. 51).

These differentiated approaches have brought serious criticism to the main arguments of constructivism. For example, Erdem and Demirel (2002) indicated that constructivism has been evolved from a learning theory to an approach to learning, which aims to understand how learners construct knowledge (p. 82). Matthews (1999) expressed a similar concern before such that "Although constructivism began as a theory of learning, it has progressively expanded its dominion, becoming a theory of teaching, a theory of education, a theory of the origin of ideas, and a theory of both personal knowledge and scientific knowledge." (p.330) Hence, the criticisms to constructivism have facets targeting one or more of these domains.

Criticisms within constructivism have been raised mainly because constructivism is described from a wide perspective including psychological, epistemological, sociological and even historical approaches. According to Hein (1991) the main argument of constructivism is that knowledge and meaning are human construction. On this argument, 'the active construction of mental representations' is shared by cognitive constructivists, however, the consideration of cognition as the individual's "organization of the experiential world" and the viability of the knowledge, defended by von Glasersfeld, is marked as radical (Kilpatrick, 1987, p. 3). On the one hand, both ideas are criticised by social constructivists for being ignorant to the cultural and political context of schooling as well as background of students that may have an influence on the variety of meaning making in classroom. In other words, this criticism focuses on the isolation of meaning making activity from its socio-cultural context (Airasian & Walsh, 1997). Social constructivism rejects Piaget’s individualistic approach and focuses on social construction. However, critics of this perspective, on the other hand, have pointed out to the chaos that may be resulted with the multiplicity of possible meanings (Airasian & Walsh, 1997). Bereiter (1994) suggested that “There is no basis for claiming that one view or another gives us a better account of how things really are, and so we are free to choose or to mix-and-match in whatever way gains us an advantage in solving problems.” (p.21)

Philosophy and science based criticisms to constructivism have their source in considering constructivism as a worldview or a philosophy. Irzık (2001) regarded constructivism in science education as a theory of learning (knowing) and teaching. However, he noted that despite the core ideas of constructivism are epistemological, there are also ontological, cognitive and semantical issues pointed out in constructivist views (p. 158). Matthews (2002) drew attention to this problem:

> “Unfortunately the different dimensions of constructivism often treated as a package deal, whereby being a constructivist in learning theory is deemed to flow on to being a constructivist in all the other areas, and being a constructivist in pedagogy is deemed to imply a constructivist epistemology and educational theory. But these aspects can all be separated and each can stand alone.” (p.124)

Another criticism in this regard is the reality construct. According to Tobin and Tippins (1993), constructivism claims that we can only know reality in a personal and subjective way. They explained this understanding with the example of gravity. There is gravity according to constructivist and we can only have an access this knowledge through our experiences. Since the objective description of gravity is not possible, our knowledge or models of gravity, which is shaped by our subjective experience with the world, cannot be considered as the “true” representation of the gravity. It is enough to claim that we can know the gravity only in the framework of our individual and socially mediated experiences (p.4).

The suppositions of constructivism and the debate on constructivism presented here are not limited to those mentioned above. However, the description and the critiques made are considered to be enough to contribute to the clarification and contextualization of the constructivism that frames this study.

1.5.2. Social Constructivist Learning Theory

Thoughts in social constructivist learning theory are based on the work of Russian psychologist Lev Vygotsky (1896-1934). Vygotsky (1978) focused on the role of environment in child’s learning. He emphasized the interaction between individual and society, social interaction in learning, and the impact of language and culture (Koç & Demirel, 2004). In this theory, the influence of interactions that occur amongst groups of learners on the construction of knowledge by an individual was described (Walker & Sampson, 2013). According to this description, individuals do not learn in isolation from others, rather they are active agents of the society and the ways through which individuals construct knowledge largely depend on where and when the knowledge is constructed, under which conditions, and in which social context the knowledge construction takes place (Yang & Wilson, 2006).

According to Vygotsky, learning depends on the development of child, but development does not necessarily depend on learning. On the relationship between learning and development, Vygotsky (1978) proposed that;

> "…learning is not development; however, properly organized learning results in mental development and sets in motion a variety of developmental processes that would be impossible apart from learning." (p.90)

In support of this interdependence of learning and development, Vygotsky introduced the construct of "zone of proximal development". According to Vygotsky, there are two developmental stages of a child: the first one is the actual development stage, which is identified as the level a child can solve problems independently. The other is the potential development stage, which is the level that a child can achieve with assistance from an adult or a more capable peer (Vygotsky, 1978). The space between two levels are called zone of proximal development. In fact, the important role of social context is supported by this construct. In other words, the zone of proximal development emphasizes the idea that the development of child does not take place only by individual learning but also needs to be supported by external world (Jaramillo, 1996). Thus, social constructivist learning theory assumes that the knowledge is constructed in interaction with society and the culture.

In relation, Vygotsky (1978) highlighted the need for a social context that supports the learning process. In this process, which requires interaction with others, tools and signs- or semiotics are important mediators (Palincsar, 1998). These are the tools, Palincsar (1998) adds, that facilitate the co-construction of knowledge and internalized for future problem solving activities. Therefore, verbal exchanges in a debate are crucial to the learning process to enable children to co-construct knowledge according to the social constructivist learning theory (Simonneaux, 2008).

Language as a social tool provides a context where students can develop distinctive modes of talking, thinking and knowing about the world. In this respect, scientific knowledge itself is considered to be a specific social language (Leach & Scott, 2002). Science learning, from this perspective, is described as the construction and use of tools to generate knowledge about the natural world (Erduran, Simon, & Osborne, 2004). One of these tools, argumentation is a discursive practice that is used in the construction and evaluation of scientific knowledge among scientific communities. It is an approach to communicate in science.

In this study, argumentation is considered from the social constructivist perspective. For this reason, in the following, the link constructed between argumentation and social constructivist theory is explained further.

1.5.3. Social Constructivist Learning Theory and Argumentation

As a way of knowing, science consists of constructed theories that offer explanations regarding how the natural world may be. In science contexts, different than the other disciplines, knowledge construction is mainly a social practice, where scientists engage in discourse about the aspects of research (McDonald & Kelly, 2012). According to Kuhn (1993), argumentation is one of the discursive practices in scientific communities used to frame claims, weigh evidence, construct warrants, and discuss alternative explanations. Argumentation, as a general term, is an essential part of an interactive dialogue of two or more people reasoning together. Specifically for science, argumentation is an essential component in making scientific claims because in an argument one needs to introduce his/her idea as a consequence of evaluating alternatives and weighing evidences as scientists do. In this regard, arguments, for instance, about the appropriateness and results of experimental design, the interpretation of data and evidence, and the validity of claims are the fundamental elements of scientific knowledge construction (Erduran, Simon, & Osborne, 2004).

Argumentation is considered to be one of the goals of constructivist science classrooms based on the social constructivist views of learning (Driver, Newton, & Osborne, 2000; Jiménez-Aleixandre, 2008; Newton, Driver, & Osborne, 1999; Walker & Sampson, 2013). For example, Jiménez-Aleixandre (2008) argues that argumentative environments are constructivist learning environments with an emphasis on the evaluation of knowledge claims. Similarly, Osborne (2005) emphasized that argumentation in science classrooms leads to significant gains in students' epistemological understanding about science in such a way that students do not only have conceptual understanding of scientific concepts but also develop an understanding of how scientific knowledge is constructed.

As a social constructivist learning practice, scientific argumentation involves both personal and social processes, such as "being introduced to the concepts, language, representations, and the practices that makes science different from other ways of knowing" (Sampson, Grooms, & Walker, 2011, p. 223). This process is a combination of individual construction of knowledge and understanding by means of the appropriation of ideas as well as the ways of communication and thinking; and interactional practices in a supportive and educative environment in a community of practice (Sampson, Grooms, & Walker, 2011). From an argumentation perspective, the students' engagement in co-construction of knowledge claims, and collaboration in the construction of high-quality arguments are important to promote the reflexivity, and to enhance the development of knowledge, beliefs, and values (Erduran, Simon, & Osborne, 2004).

In sum, the assumptions and suggestions of social constructivist learning theory are closely related to the goals of argumentation in science education. This connectedness is explicated further in Chapter 3, p.48. In conclusion, this study is grounded on the social-constructivist theory of learning and argumentation is considered as central to social construction of knowledge, epistemic beliefs, and values regarding science.

1.6. Guidelines to the organization of the dissertation

Given the characteristics of the methodology used in this research (see 2.3.2. The features of the design, p.30), this dissertation was structured in a different format. In their review paper about the qualitative research designs, Creswell et al. (2007) argued that "Researchers should begin their inquiry process with philosophical assumptions about the nature of reality (ontology), how they know what is known (epistemology), the inclusion of their values (axiology), the nature in which their research emerges (methodology), and their writing structures (rhetorical)" (p.238). Thus, in Chapter 1, I wrote about the social constructivist learning theory in science education as well as its relation to argumentation. This was my perspective towards learning in general and in science education from a psychological approach. This part was an account of how I relate argumentation to social constructivist view of learning and value it as an important component of learning science. In Chapter 2 (p.19), I explained my research orientation and legitimatized the use of EDR in this research. Hence, the ontological and epistemological assumptions of this study are discussed in Chapter 2. The constructivist-interpretive approach to the research clarifies my ontological and epistemological assumptions. Therefore, the constructivist view mentioned in Chapter 1 and the one in Chapter 2 is different. As it was explained, in Chapter 1, constructivism, and specifically social constructivist view of learning, is taken into account as a psychological approach to learning, whereas in Chapter 2, the ontological perspective of constructivist paradigm was considered. Beginning with Chapter 3, the details of the research process were explicated. For example, in Chapter 3 (p.48), three main core processes in EDR, through which the design solution planned for actual use- the product of this study-was developed, were described. The chapter is descriptive in methodology and reflexive in writing. Chapter 4 (p.207) offers the details regarding the theoretical contribution of this study, which is the exploration of the instructional strategies that the teachers employed while planning and implementing argumentation-based science lessons. The last chapter (Chapter 5, p.269) was an analytic auto ethnographical account of my experiences as a researcher and the facilitator of the graduate course.

CHAPTER 2

THE RESEARCH PARADIGM AND THE DESIGN OF THE STUDY

This section presents a full account of the research paradigm, design and implementation. Within this perspective, the chapter gives details of the overall research paradigm, methodology, and design in addition to the justification regarding the selection of the educational design research (EDR), the leading theory and models in conducting EDR, the organization of this study based on a generic model, as well as the approach to trustworthiness in this study. This chapter also legitimizes the organization of the chapters in this dissertation.

2.1. The Research Paradigm: Constructivist Interpretive Research

The statement of the research paradigm with its ontological and epistemological presuppositions that inform the specific work is quite necessary in a study because although it seems that many elements are similar across research designs; these similarities may cover the important distinctions in their approaches to research (Schwartz-Shea & Yanow, 2012). The researcher should make these distinctions clear first to illustrate how the research paradigm materialize the research and second to inform readers in terms of researcher's understanding of what constitutes valid research and which research methods are appropriate for the construction of knowledge in a given study.

Here, in this study, the constructivist-interpretive research paradigm informs the research design and determines the research methods. According to Denzin and Lincoln (2005) qualitative research paradigms can be classified into four philosophically distinct categories as positivist-post positivist, constructivist-interpretive, critical postmodernist (Marxist-emancipatory), and feminist-post structuralism. Among these, discussions of interpretive research are generally positioned in comparison with the discussions of positivist approaches since the methodological concepts from the latter are dominant for a long time in educational research (Schwartz-Shea & Yanow, 2012).In the following section, I will follow the same pathway to explicate the presuppositions associated with the constructivist interpretive research paradigm and this study.

The positivist research are those research that hold a realist perspective ontologically and objectivist approach to research epistemologically. A range of schools including social positivism, evolutionary positivism, critical positivism, logical positivism, and mid-twentieth century post-Popperian neo positivism can be listed in positivist research (Schwartz-Shea & Yanow, 2012). Logical positivism, which was popular in early twentieth century, can be described with its approach to understand human behaviour through observation and reason as essential means. In this thought, researchers should be in search of true knowledge that is based on the experiences gathered by senses and verified- later in the mid-twentieth century, can be falsified- by observation and experiment. These verification and falsification methods of positivistic thought are still influencing social sciences (Schwartz-Shea & Yanow, 2012). At the ontological level, according to logical positivists, the reality can be measured quantitatively by means of instruments which are independent of the subjective existence of the researcher and so the knowledge is objective. Therefore, logical positivist researchers adopt standardized scientific measurements and establish systematized scientific processes for knowledge in order to ensure the objective description of the phenomena (Breuer, Mruck, & Roth, 2002). However, it is important to note that, today, in addition to quantitative methods, positivist research can utilise qualitative methods of research as well (Gephart, 1999; Schwartz-Shea & Yanow, 2012). Although continued to influence educational research, the dominance of positivist and post positivist paradigms were challenged by critics from constructivist interpretive and later by critical theorists mainly because of the emphasis positivistic thought put on the objective and independent reality (Creswell, 2013; Packer, 2011; Schwartz-Shea & Yanow, 2012).

Instead, the constructivist interpretive thought, which guides this study, encompasses a range of schools with different approaches to research but these schools are united by their constructivist ontology and interpretive epistemology (Burrell & Morgan, 1979; Schwartz-Shea & Yanow, 2012). Constructivist ontology assumes that there are multiple realities consisting of people's subjective experiences of the external world constructed through experiences and interactions with others (Denzin & Lincoln, 2005). The interpretive researchers in social sciences not only explain these constructions but also make meaning out of these experiences and interactions (Demir, 2012; Schwartz-Shea & Yanow, 2012). Interpretive researchers assume that there is no knowledge and so as meaning, which is independent of the human thinking and reasoning (Gephart, 1999). Therefore, at the epistemological level, the meaning and so the knowledge is actively and collaboratively co-constructed by the researcher and the respondents (Denzin & Lincoln, 2005). Hence, the interpretive research paradigm is concerned with meaning as it is from the subjective understanding and experiences of individuals.

As the meanings are co-constructed by individuals, there is possibility of multiplicity of meanings in interpretive research. This possibility of multiple realities makes the context critical for interpretive researchers because the specific circumstances of the context structure the things as they are (Schwartz-Shea & Yanow, 2012). Therefore, interpretive researchers seek meaning within specific settings, that is, they focus on context-specific meanings in the analysis (Reeves & Hedberg, 2003; Schwartz-Shea & Yanow, 2012). The meaning is shaped by the instances of the time and context. Since it is individually and collaboratively constructed, the meaning can only be understood in its context. The same individuals, including the researcher, may respond differently in different circumstances. A different researcher, even if she uses the same interview questions and same data analysis methods, may co-construct a meaning that differs in content and organization. Qualitative positivist studies refrain from such multiple interpretations, and researchers in positivist orientation address the inter-rater reliability measures to control for this 'threat'. However, in interpretive research, this is not conceived as a threat to trustworthiness (see 2.5. Trustworthiness, p.44). Instead, in interpretive research, researchers look for being as clear as possible about the evidence and the ways data generated as well as describing the contribution by researchers' background (Schwartz-Shea & Yanow, 2012). Thus, interpretive researchers pursue understanding within context; that is, try to figure out how the individuals involved in perceive the context and why they respond in particular ways in that context.

Constructivist interpretive researchers believe that there is no step-by-step procedure or a single route to take in the construction of knowledge as long as it is characterized by in-depth investigation of the phenomenon. The interpretive approach enables the researcher to explain the complexity of human meaning-making in specific settings and the subjective meanings that motivate social actions with the intention of drawing inferences or evaluating the consistency between knowledge constructed and abstract patterns in theory (Aikenhead, 1997). That is, the interest in interpretive research is to contribute to the evaluation or refinement of the interpretive theories rather than generating a new theory. Hence, the methodologies associated with constructivist interpretive research is meaning oriented ones, such as interviewing and participant observation, which rely on the interactions between researcher and participants (see 2.4. Data generation and analysis, p.38). These methods are also used in qualitative-positivist studies in generating data but the difference can be realized in how the data are generated-e.g. whether data are co-constructed or not-, orientation toward the enactment of data generation methods-e.g. whether it is participatory/ collaboratively or not-, and in analysing data- e.g. whether it is interpretive/ reflexive or not (Schwartz-Shea & Yanow, 2012). The researchers' role in a large section of constructive interpretive research is being within the community and participating in natural setting by observing people, interacting with them and even taking part in the course of everyday activities as a natural member of that community. Because the data is co-constructed in constructive interpretive studies, the researcher cannot objectively mirror or measure the data like an outside observer. On the contrary, the researcher herself is thought to be a research instrument in interpretive study because her personality and approach to research characterizes the study. These characteristics and research methods in constructivist interpretive research are originated from hermeneutics and phenomenology (Schwartz-Shea & Yanow, 2012).

2.1.1. Hermeneutics

Hermeneutics is a branch of interpretive philosophy, which concerns with theories for interpreting knowledge (Schmidt, 2006). The meaning of hermeneutics, today, is determined by Gadamer (1975) in his book, named Truth and Method. Gadamer (1975) described hermeneutics as a philosophical theory of knowledge, which claims that interpretation and application or experience is fundamental for all cases of understanding.

Hermeneutics is also considered to be a mode of analysis for interpretation of the meaning, which is unclear to human beings (Gadamer, 1975). According to Gadamer, the hermeneutic understanding is circular in a sense that "the movement of understanding is constantly from the whole to the part and back to the whole" (Gadamer, 1975, p. 302). This logic is consistent with the iterative character of constructive interpretive studies that researchers' presuppositions and understandings are assessed several times by going back to theories of knowledge and to the human beings they study with for meaning-making in context (Schwartz-Shea & Yanow, 2012).

The questions addressed by hermeneutics involve, according to Schleiermacher, all cases of understanding spoken or written language, while according to Gadamer, it is not limited but any case of understanding needs interpretation (Schmidt, 2006). In other words, the task of modern hermeneutics encompasses everything that needs understanding including all forms of communication as well as prejudices, and pre-understandings (Schmidt, 2006). The validity of any interpretation depends on first how language is understood and second, essentially on a theory of knowledge.

2.1.2. Phenomenology

Literally, phenomenology is "the science of phenomena" and it concentrates on "the study of consciousness and the objects of direct experience" (Oxford Dictionaries, 2014; Smith, 2013) with Edmund Husserl (1859-1938), Martin Heidegger, Jean-Paul Sartre, and Maurice Merleau- Ponty being its most well-known exponents (Creswell, 2013; Smith, 2013). The main idea is that if science was supposed to fulfil its mission of providing rational knowledge for the well-being of humanity, then science must pay attention to human experience as much as it does to the physical world (Churchill & Wertz, 2001).

Thus, the task of phenomenology is the meaning-making as experienced from the perspective of the individuals within their social, political, cultural, and other settings (Creswell, 2013). In a phenomenological study, researcher describes the common meaning but she estranges herself from this common meaning so she can reflect on it and make sense of it (Creswell, 2013; Schwartz-Shea & Yanow, 2012). A phenomenologist collects data from those individuals who experience the phenomena through interviews and observations, inquiries into gathering deep information, and represents this information to have a universal description of the phenomena (Creswell, 2013; Lester, 1999). However, the researcher does not only describe the phenomena, rather she mediates between alternative meanings, which makes the phenomenology an interpretive process (van Manen, 1990).

In overall, the key ideas of interpretive research coming from hermeneutic and phenomenology philosophies are summarized as the following (Schwartz-Shea & Yanow, 2012):

- The artefacts created by humans carry those meanings, which are constructed at the time and place of creation.
- Those artefacts may not have the same meanings at another context for anybody else; that is the knowledge is contextual as well as the *knower* and the researcher.
- Meaning-making is not a one-shot event but rather it is a process, which has no specific starting or end point. Meaning is co-constructed and reflects what the researcher and the participants understand at that specific time and place.
- Meaning-making embodies ways humans experience the world.
- Meanings are constructed individually and socially, so there is a co-construction of knowledge involving all individuals in the setting.
- Language is more than a mirror that reflects what the person thinks, but it is an active agent in construction of thoughts, and shaping the world of meanings.

While deciding, planning and conducting this study, I beard in mind all those presuppositions.

There are some implications of these philosophical assumptions on research. For example, from the perspective of constructive-interpretive tradition, the purpose of inquiry is understanding and description in search of meaning (Racher & Robinson, 2002). The research focuses on the process of meaning-making, which is negotiated, sustained and modified in the context of human actions (Schwandt, 1994). In other words, the purpose of inquiry is “studying humans as beings who live in particular cultural and historical forms of life and who are made and make themselves as specific kinds of subjects” (Packer, 2011, p. 5). Therefore, research methodology focuses on the lived experiences of human beings and on the way they attach meaning to their subjective reality (phenomenology) (Holloway & Wheeler, 2013). The interpretive researcher engages in contexts, where she seeks for understanding human experiences in their context to make sense of the multiple interpretations, values and interests as part of the research process (hermeneutics). This engagement requires the researcher to be a part of the context as well as the primary instrument of data collection and analysis. The investigator is interactively connected to the objects of the investigation and the findings are constructed as the investigation proceeds (Racher & Robinson, 2002). Thus, the constructivist-interpretive researchers usually rely on either qualitative or mixed data collection methods or analysis (Mackenzie & Knipe, 2006). These methods include phenomenology, hermeneutics, grounded theory, ethnography, and others (Racher & Robinson, 2002).

In this study, qualitative methods of research were followed to answer the research questions. In the following section, the research method of this study was explicated in connection with the philosophical assumptions explained so far.

2.2. Research Method: Qualitative Methods of Research and Auto-Ethnography

The research paradigm along with the ontological and epistemological assumptions informs the logic of inquiry for a study. The logic of inquiry- or research methodology- is carried out or enacted by means of particular tools- the research methods- which move the inquiry from the underlying assumptions to the research design and data collection (Myers, 2013; Schwartz-Shea & Yanow, 2012). The most common classification of research methods, based on the distinctions about the nature of knowledge, is qualitative and quantitative.

Qualitative research is logic of inquiry, which is characterized by the traditions associated with the philosophical orientation to research, such as foundationalism, positivism, post positivism, and interpretive tradition. Therefore, any definition of qualitative research must reflect the perspectives, and/ or methods connected to the research paradigm (Denzin & Lincoln, 2003). Nonetheless, Denzin and Lincoln (2005) offer a generic definition of qualitative research as “a situated activity, [which] involves an interpretive, naturalistic approach to the world. [Qualitative researchers] study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them” (p.3).

The naturalistic facet of the qualitative research allows for having an incomplete design in the beginning of the study since it is difficult to predict the way interactions and experiences will be shaped due to the possibility of diverse experiences, perspectives and histories in the context. Thus, an interpretive qualitative researcher should consider a design to evolve or to allow for alterations in research process. In this study, I employed educational design research, which involves several iterative cycles, intent for a better understanding of the phenomena and so the products of the study (see 2.3. Research design: Educational Design Research, p.28).

In terms of the way in which data were collected and analysed, as well as the type of generalizations and representations derived from the data, this study is a qualitative research. I focused on explicating the interactions of mutually shaping influences and to the independent realities and experiences of the participants, and myself, as a researcher. This positioning of myself in this methodology compelled me to act as a researcher and participant, and to observe myself as well as the participants (Schwartz-Shea & Yanow, 2012). In order to eliminate the distinction between these dual roles, I generally applied to auto-ethnography in my writing.

2.2.1. Auto-ethnography

In the Encyclopaedia of case study research, auto-ethnography is defined as “a form or method of research that involves self-observation and reflexive investigation in the content of ethnographic field work and writing” (Maréchal, 2010, p. 43). Auto-ethnographic research is a form of self-reflection and writing that illustrates the researcher’s personal experience along with wider cultural, political, and social meanings and understandings (Ellis, Adams, & Bochner, 2011). As a method, auto-ethnography combines tenets of autobiography and ethnography.

Auto-ethnography, likewise autobiography, includes writings of researcher’s past experiences retroactively and selectively (Ellis, Adams, & Bochner, 2011). However, like ethnographers, auto-ethnographers must consider and analyse about these experiences and make connections to cultural experiences. The purpose is providing readers with the aspects of culture meaningful for research. Auto-ethnographers accomplish this purpose by means of making critical comparisons between personal experiences against existing research, interviewing, self-observation, and examining relevant cultural artefacts (Chang, 2007; Ellis, Adams, & Bochner, 2011). In other words, as auto-ethnographers describe and look critically at their own experience, they also mirror to the social context they are in and their interaction with this context. In this sense, auto-ethnography is also a social constructionist project (Ellingson & Ellis, 2008).

Auto-ethnography differs from ethnography in that auto-ethnographers focus on their subjective experiences rather than the beliefs and practices of others (Hayano, 1979). Consequently, auto-ethnography studies involve a high level of subjectivity and the researcher's influence on research. Unlike qualitative studies that attempt to limit researcher's subjectivity, auto-ethnography embraces, acknowledges and foregrounds it (Bochner & Rushing, 2002). Subjectivity is indeed not avoidable in auto-ethnography because auto-ethnographers are the primary subject of the research (see 2.2.3. Subjectivity, p.27). However, as Walker and Unterhalter (2004) warn that "In excavating our own subjectivity, the point is not to produce research as therapy or stories for their own sake, but a disciplined and reflexive understanding of the known and the knower' (p.290). Reflexive understanding, here, is a concept or method that auto-ethnography attempts to bring into research (Alsop, 2002; Chang, 2007), which is described as researcher's being aware of her own influence on the research (see 2.2.2. Reflexivity, p.26).

There are different forms of auto-ethnography depending on the researcher's focus on self and her interactions, study of others, traditional analysis, power relationships and interview context (Ellis, Adams, & Bochner, 2011). Here in this study, I followed the genre defined by Anderson (2006) as analytic auto-ethnography. In analytic auto-ethnography, researcher is a complete member in the research group or setting, and the research agenda is oriented towards improved theoretical understanding of phenomena (Anderson, 2006). Additionally, analytic auto-ethnography is characterized by the researcher's narrative visibility, analytic reflexivity, and dialogue with others other than self (Anderson, 2011). Therefore, in this research, there are my perspective and evaluation not only of the participants but also of myself. Therefore, reflexivity and subjectivity are two important terms in this study.

2.2.2. Reflexivity

Reflexivity, which is an essential component of interpretive research, refers to "researcher's active consideration of and engagement with the ways in which his own sense making and the particular circumstances that might have affected it, throughout all phases of the research process" (Schwartz-Shea & Yanow, 2012). In other words, reflexivity is subjective study of researcher's self-consciousness and of his social experiences, which may have an effect on research findings, researcher's conclusions, and interpretations drawn in a study, with reference to theories (Creswell, 2013; Schwartz-Shea & Yanow, 2012). Therefore, reflexivity is a methodological consideration in interpretive studies.

Reflexivity as a methods practice is not identical with reflective practice in its implementation (Matthews & Jessel, 1998; Nagata, 2004; Ryan, 2005). Reflexivity is enacted when researcher's observations or actions in the context affect the research circumstances in each interaction with others in a relevant culture (Sullivan, 2002). In regulating reflexivity, the researcher should engage in systematic consideration of her own characteristics and her potential role in the field setting as well as how these might have influence on accessibility to others, their ideas and for researcher-participant interactions (Schwartz-Shea & Yanow, 2012; Waghid, 2002).

Reflexivity allows researchers to advance personal responsibility for the research by concentrating on the ways in which instances of their position interfere with their research accounts and their claims based on those accounts (Ryan, 2005; Schwartz-Shea & Yanow, 2012). In this research, I agree with Smyth and Shacklock (2002) that being reflexive while writing research means being honest and ethic in research, and with Packer (2011), who adds reflexivity a special status in social sciences and their ability to produce knowledge claims.

2.2.3. Subjectivity

Qualitative methodology rejects that neutrality, which is generally equated with objectivity, is possible. According to qualitative methodology- yet no method is methodologically neutral- subjectivity of the researcher is unavoidable in scientific research (Ratner, 2002). The values the researcher brings to the research along with the researcher's life experiences and other social, cultural, and political factors contribute to his ontological and epistemological pre-suppositions related to the type of research that he chooses to engage in (St. Louis & Calabrese Barton, 2002).

Considering auto-ethnographers, Foley (2002) notes that most of them are responsively subjective. They refuse to speak "in a rational, value- free, objective, universalizing voice" (p. 474) because in auto-ethnography, the researcher writes her experiences, and her evolution as a researcher and as a human being in a culture. As Packer (2011) states that in our interaction with a person or a situation, we don't merely test our hypotheses or look for answers to our research questions but we are challenged by our encounters with all, and so we learn, we are changed, and we mature (p.5). Moreover, these experiences and their transfer to the paper are bounded with our values since those values shape our knowledge of the world (Ratner, 2002). Therefore, researchers are encouraged to take these dynamics into account and consider how these might affect the research process.

In this study, my understanding of subjectivity is having claims, which are theory and value-laden. I may not be aware of all my pre-suppositions and values inherent in my research, but the fact that they exist and they are influential throughout the research process. However, in my understanding, subjectivity in this sense is not a bias or threat to my research; rather, it is inevitable and in some cases invaluable (see 2.5.4. About bias in interpretive research, p.46).

2.3. Research Design: Educational Design Research

Interpretive research essentially proceeds with flexible designs due to field realities. Schwartz-Shea and Yanow (2012) indicate that these realities are related to first the researcher's own development and second to researcher's position in the field setting. That is, interpretive researcher begins research with insights from existing literature and prior knowledge of the field, but during her investigation her knowledge as well as beliefs, values, theoretical commitments build on themselves in iterative and recursive cycles. Throughout this process, researcher's sense-making and learning deepen with her experiences in the field. In light of such ongoing evolution, the initial research questions might be expanded or elaborated. Second, in interpretive research, researcher participates in the setting. Therefore, researcher lacks control over the settings of research participants and their individual or substantive change (Schwartz-Shea & Yanow, 2012). This position of the researcher in the setting does not allow a fixed design and flawless implementation of the plans so the design must be flexible in interpretive research.

Hence, as a flexible research design in this study, I utilized "Educational Design Research" (EDR). EDR is defined as "a genre of research in which the iterative development of solutions to practical and complex educational problems also provides the context for empirical investigation, which yields theoretical understanding that can inform the work of others" (McKenney & Reeves, 2012, p. 7). Also called as design-based research, through this methodology, theories of learning inform the design of educational interventions and are informed by the implementation of these designs (Kelly, Lesh, & Baek, 2008; Majgaard, Misfeldt, & Nielsen, 2011).

In the design of this study, the educational problem was the difficulty experienced by science teachers in implementing argumentation in their classrooms (Simon, Erduran, & Osborne, 2006). The study aimed to develop the theoretical and pedagogical understanding of teachers in regard to argumentation. In addition, the study also aimed to contribute to the theoretical understanding about the pedagogy of argumentation by means of the products of research relevant for educational practice.

EDR is characterized in relation to *Pasteur's quadrant* (McKenney & Reeves, 2012). As described in Stokes' (1997, cited in McKenney & Reeves, 2012) study, the Pasteur's quadrant is a graphical representation of the research in terms of two variables: One is the quest for fundamental understanding, and the other is consideration of use. In this quadrant, EDR is considered to be "a form of linking science, in which the empirical and regulative cycles come together to advance scientific understanding through empirical testing during the development of practical applications" (McKenney & Reeves, 2012, p. 10). In this line, this study is a blend of *empirical and regulative cycles*, in which participants and also I advanced theoretical understanding of argumentation and reflected this understanding in participants' practical applications.

Two prevailing orientations to educational design research are *research conducted on interventions* and *research conducted through interventions* based on whether the intervention is a means of inquiry or is the focus of the study (McKenney & Reeves, 2012, p.23). This research is an example of *educational design research conducted through intervention*. Here, the intervention, which is the course named as 'Argumentation in Science Teaching and Learning', is a means through which deeper insight is sought into pedagogy of argumentation and related theory-practice gap. The theoretical contributions emerging from this research are related to teaching- in terms of patterns in how teachers develop pedagogical knowledge in classes during argumentation-based lessons- as well as design- in terms of a model describing instructional design trajectory in relation to professional development of teachers about argumentation theory and practice.

2.3.1. Rationale for an educational design research

There are two reasons that led me employ EDR in this study. One of them is the existence of weak consistency between the number of research published in educational journals, including high quality educational research, and the development of educational outcomes around the world (Reeves, McKenney, & Herrington, 2011). In their critical article, Reeves et al. (2011) drew attention to this problem in educational research and they claim that most of the educational research published, even those that report innovative educational treatments- though most of them with weak results-, at all levels of education have either low or no impact on the improvement of educational outcomes. The researchers emphasize the critical importance of EDR to overcome the barriers such as "*the mind-set of researchers"*, and "*the limited view of what constitutes research"* (p.58) as well as the problem of isolated educational research and practice.

Another reason of using EDR as a research methodology in this study is because the process of EDR supports transformational teacher learning (see 3.2.6. Teachers' Learning, p.133). Transformational teacher learning (TTL) is achieved when the theoretical background of research ideas presented to teachers and then they are invited to explore how those ideas might be translated into their classroom practice (Kennedy, 2005). According to Kennedy (2005), teacher empathy with project aims and teacher motivation to engage with ideas through reading and discussion are fundamental to TTL. Fraser, Kennedy, Reid and McKinney (2007) suggested that formal, planned learning opportunities to be augmented by more informal, incidental ones for TTL so that teachers have a greater ownership and control of the processes in regard to various aspects of the individual and social learning (Fraser, Kennedy, Reid, & Mckinney, 2007).

The theoretically-oriented, responsively-grounded and collaborative features of EDR- that are described below- ensure these requirements for transformational teacher learning.

2.3.2. The features of the design

The common features of EDR are echoed in this study. These features of EDR are being theoretically-oriented, interventionist, collaborative, responsively grounded, and iterative (McKenney & Reeves, 2012). In the following, these features and how they are reflected in this study were explained in brief.

Theoretically oriented

According to the theory-laden nature of science, all observation is preceded by theory and conceptual knowledge. EDR is not an exception. As in the most disciplined research, in EDR, existing theories frame inquiry and the results of the inquiry either builds up or further elaborate the initial theoretical understanding (Kelly, Baek, Lesh, & Bannan-Ritland, 2008). That is, in EDR, theoretical propositions are used to frame the research and the design of a solution to a real problem and the process ultimately help construct or develop theoretical understanding through empirical testing (McKenney & Reeves, 2012). In contrast to most educational research, which are efforts of a search for matches between educational interventions and problems of teaching and learning through theory-testing, EDR puts the theory into the centre of research in shaping of the designs that address problems (Reeves, McKenney, & Herrington, 2011) and furthermore design plays an important role not only in the evaluation and refinement but also in the development of the theory (Edelson, 2002).

This study was grounded on argumentation theory and the research related to the teachers' professional development in argumentation. The literature on teachers' professional development in argumentation is reviewed (see 3.3.1. Science teacher education on argumentation, p.139) and the graduate course, in which this study took place, was designed based on the empirical research in this area (see 3.2. Analysis and Exploration: Understanding argumentation in science education and conceptualizing the research, p.49 and 3.3. Design and Construction, p.139). The results of this study draw upon and contribute to theoretical understanding related to professional development of teachers in argumentation, to argumentation in science teaching and learning, and to principles for guiding similar design efforts in argumentation.

Interventionist

In addition to contributing to theoretical understanding, EDR also strives to improve educational practice. Therefore, through such interventions that educational products, processes, programs, or policies, EDR brings transformation through theory-laden design and solutions to real problems through practice in authentic setting. EDR is interventionist because the aim is to make a real change on the ground by means of creative solutions informed by theory, empirical testing and active involvement of the participants in the process (McKenney & Reeves, 2012; Schwartz, Chang, & Martin, 2008).

The interventions in this study- alongside the development of theoretical understanding- were related to two themes, including educational products (e.g. lesson plans and learning activities) and programs (e.g. the graduate course). That is, in the study, both the activity of developing solutions to teachers' inefficacy in implementing argumentation in science classrooms, and empirical testing of these solutions in the context of a graduate course took place.

Collaborative

EDR is conducted in collaboration with the actors connected to the problem at hand. During EDR, researchers and practitioners learn from each other while continuously adapting the interventions to reach the goals (McKenney & Reeves, 2012; Zawojewski, Chamberlin, Hjalmarson, & Lewis, 2008). EDR has the potential to provide a direct link between research and practice by means of collaboration among practitioners and researchers in the identification of significant teaching and learning problems, in the development of creative solutions to these problems based on existing design principles, and in the evaluation and refinement of solutions and design principles (Kelly, Baek, Lesh, & Bannan-Ritland, 2008; Reeves, McKenney, & Herrington, 2011).

This study was also the collaboration of several partners. First of all, the participants and I, as the researcher, were always in communication face to face, by e-mail and by phone. We collaborated to revise and refine the graduate course and to prepare the learning tasks and plans that would be practiced in schools. Second, I was consulting to my advisor almost each week about the content of the graduate course in terms of the progress, learning activities, speakers -if there was any- and readings. Third, I was also collaborating with a participant observer, who was a graduate student and participating in most of the course as the other participants, about the progress from the perspective of the participants and to what extent the research was on target. The participant observer was not involved in data generation but she was a data source as well. Moreover, the participants worked in collaboration with the schools and science teachers in the schools to arrange practices.

Responsively Grounded

The products as well as the process of EDR are shaped by not only the researcher but also by the expertise, literature, and field testing of the participants. The experiences in the real world along with the theoretical insights adjust the course (McKenney & Reeves, 2012). This was also true for this study such that the initial design of the graduate course and the products went through continuous revise and refinement by the concerns raised by the participants and their experiences in the real science classroom contexts. Therefore, this study is a reflection of the complex realities of teaching and learning contexts both in a graduate course and in real science classrooms and how the research responded accordingly.

Iterative

As in most of the scientific research, EDR has no certain steps to follow to reach a conclusion. Rather, through the development of insights and interventions, EDR involve cycles of inquiry where multiple iterations of investigation, testing and empirically-based refinement of ideas and actions take place (Hjalmarson & Lesh, 2008; McKenney & Reeves, 2012). According to Majgaard et al. (2011), the iterative cycles of EDR contributes to the understanding of the context, and appreciation of the uniqueness of each context while developing theories that is general enough to inform others working on similar contexts.

This study is one large inquiry, within which two sub-studies completed. The graduate course was given in two semesters. Each semester, the research process designed and refined with its own complete cycle of inquiry and sound chain of reasoning. The insights and the interventions of the earlier semester acknowledged the later one and the design research evolved over time. The structure of each inquiry was described in the (see 3.4. Evaluation and Reflection, p.168).

In summary, considering the above mentioned features and how these features were reflected in this study, this research is an example of educational design research. In the following, the models of EDR and how they worked in this study were described.

2.3.3. Theoretical foundations and models in conducting EDR

The model of educational design research utilized in the writing of this study was developed by McKenney and Reeves (2012) based on two leading field of educational research; instructional design and curriculum development, and several design approaches detailed in the book *Conducting Educational Design Research* (p.73). Before the model was proposed in year 2012, this study had started in the guidance of constructivist- interpretive research philosophy- which is introduced at the beginning of this chapter as the research paradigm (see 2.1. The research paradigm: Constructivist Interpretive Research, p.19), and in the guidance of a model of EDR, which is described below.

The EDR model that I took account of was *Design Research from a Learning Design Perspective* by Gravemeijer and Cobb (2006). The researchers described their approach to design research through an example of a learning design on statistics education. They developed their design experiment in three phases: In the first phase, which is named as preparing for the experiment phase, the preliminary goal was clarifying the theoretical intent of the study and, in light of this, formulating a local instruction theory that will be further elaborated and refined throughout the study. Design experiment is conducted in the second phase, which is experimenting in the classroom phase. In this phase, the researchers took the responsibility for the learning of a group of students. Conducting retrospective analyses, the third phase, contributes to the theory by means of the analyses of the entire data set. Although they are discussed separately, these three phases are intertwined in iterative cycles in the process (Cobb & Gravemeijer, 2008; Gravemeijer & Cobb, 2006).

In sum, this study was founded on the constructivist- interpretive research tradition and abovementioned design research model. Overall, this literature and some other models of EDR were taken into consideration by McKenney and Reeves (2012), and they constructed a generic model for conducting EDR. This model is used to describe the progress in this study.

Generic model for conducting educational design research.

Compatible with the several theoretical frameworks and models described in earlier sections, McKenney and Reeves (2012) created a generic model of educational design research. According to the model, there are three main core processes in EDR before developing interventions that are planned for actual use. The first core process is analysis and exploration, the second is design and construction, and the third one is evaluation and reflection (McKenney & Reeves, 2012). These processes are not steps to follow but rather they are intertwined, iterative, and flexible core activities that should be undertaken. Figure 1 depicts these core processes in a generic model (McKenney & Reeves, 2012). Following, how these core processes were handled in this study was described.

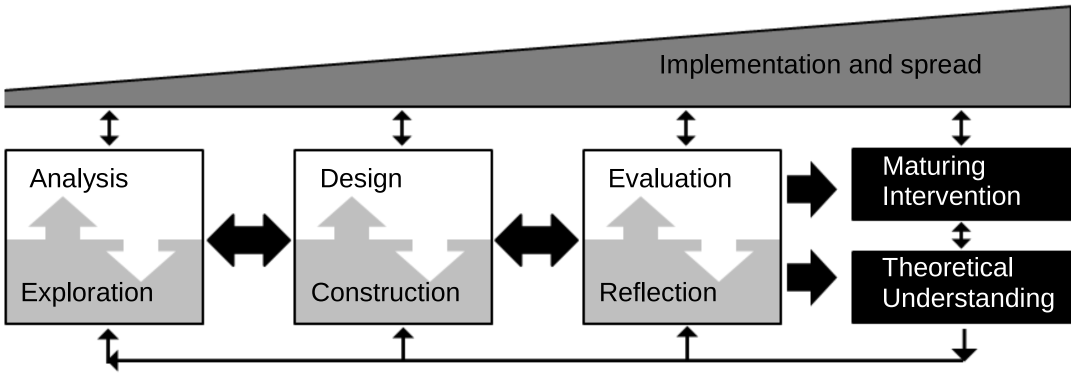


Figure 1 Generic model for conducting design research in education (McKenney & Reeves, 2012)

Analysis and exploration.

In this process, there are two goals: The first goal with regard to analysis is identifying or conceptualizing the problem. The research can achieve this goal through contextual analysis, needs assessment, and literature review. As important as identifying the problem, initial perception of the problem by the stakeholders and causes of the problem are also concerns for the researcher to think about.

In this study, these concerns were addressed through literature review and pre-interviews. Literature review in the analysis process of this study was carried out about many aspects of argumentation in science education and the problems associated with the implementation of argumentation in science classrooms along with the philosophical orientations in educational programs linked to the integration of argumentation into science curriculum (see 3.2.1. Argumentation, p.49). Literature review helped me to gain insight to both the theoretical inputs to understand the problem and practical aspects such as the data collection and analysis procedures that I would use to frame the research. Pre-interviews served as a starting point to clarify whether the draft problem statement derived from the literature review is perceived in the same way by the participants and what could be the possible ways to initiate a design in solution of the problem. Pre-interviews provided me with the participants' viewpoint in terms of the integration of argumentation or other kinds of discourse- since they were not familiar to argumentation before attending to the course- and their perceptions of any problems accompanying with the implementation of discourse in their classrooms (see Pre-interviews to explore participants' understanding of the problem, p.114).

The second goal with regard to exploration is constructing a richer understanding of the problem as well as the attempts to solve it. Here, the researcher investigates the possible solutions existing and tries to refine the understanding of how others addressed the problem and went about it usually in an informal way (McKenney & Reeves, 2012). There are three common activities suggested for the exploration: visits to the physical places directly related to the problem, e.g. site visits to schools; professional meetings with the researchers who have been already working on the issue, for example, in conferences, and establishing networking (McKenney & Reeves, 2012).

In order to explore the ways to look at the constraints experienced by the teachers in the implementation of argumentation in science classrooms, which is the succinct problem statement in this study, I attended to the research conferences, such as European Science Education Research Association Conference held in Lyon, France in 2011 and National Association of Research in Science Teaching held in Philadelphia, the United states in 2010, I visited the professionals working on the problem or contacted with them via e-mail, and I argued about my proposal with my dissertation examining committee in biannual meetings. These interactions helped me to identify the design requirements that relate to the problem, setting, and participants of this study.

Design and construction.

This phase of EDR is characterized by attempts to construct a well-considered design solution, which has a theoretical background in science education literature and in practice. The design and construction phase is not a one-shot endeavour in EDR but rather it is a phase that may be revisited several times and may result with refined outputs each time. The first goals with regard to design are exploring and mapping solutions (McKenney & Reeves, 2012).

With the aim of constructing an educational design, which is a graduate course for teaching and learning argumentation in this study, I collected a set of design solutions that were constructed and implemented by other researchers for long periods. In the light of these design solutions, potential ways of implementing a professional development for teachers were explored in collaboration with researchers and content experts as well as third parties from Ministry of Education, Department of In-service Teacher Training. Overall with these meetings, the ideas generated were discussed considering the feasibility and viability of each, and checking the ones that seem the most promising. The design process helped me to specify my long-range goals and served as a guide for me to construct an initial design proposition. The initial design proposition as well as design document, which describes the evolution of ideas during EDR are described on Chapter 3. The development of educational design: A graduate course on argumentation in science teaching and learning, p.48.

The construction process is aimed at first generating initial prototypes in the form of educational material, such as educational software, or in the form of educational representation, such as guidelines for a teaching method, and second gradually elaborating those (McKenney & Reeves, 2012). The prototype is revised several times until a successive approximation of the desired intervention, which is both informed by the theory and the research, is achieved (McKenney & Reeves, 2012).

The prototype in this study had two components when it was initiated: a product component, which was planned to be a learning design software that would aid teachers in creating argumentation-based science lessons; and a process component, which is the dissertation itself as a sample of successive educational design research and as a guide to enact a graduate course for teaching and learning argumentation in science education. However, early prototypes are not generally representative of all elements of a product solution, rather they evolve to more feasible and enduring ones (McKenney & Reeves, 2012). In this study, because of the limitations experienced during evaluation and reflection phase and described in detail in 3.3.3 Initial attempts for a design solution, p.160, the product component was transformed from learning design software to a graduate course program with a collection of lesson plans and lesson videos as well as students' artefacts, which were initially planned to be integrated into the software. The process component of the study was evaluated through empirical testing strategies and methods. In other words, the prototype of the educational design, which is a graduate course, was implemented in two semesters with major and minor revisions to increase its functionality in collaboration with researchers and participants based on the findings from evaluation and reflection phase. The evolution of the process through empirical testing is described in detail in 3.4. Evaluation and Reflection, p.168.

Evaluation and reflection.

During the evaluation and reflection process, the constructed design solutions are empirically tested by the researcher and further the researcher reflects upon the findings in order to refine the theoretical understanding and the intervention. First, the researcher frames the inquiry and collects empirical evidence with regard to evaluation. There should be questions in researcher's mind for each level of EDR. For example, questions about the intentions, assumptions, and alignment of design at the early stages; questions about the theoretical and practical contributions of the design; and questions about the effectiveness and impact of design are investigated during the evaluation process. The goal with regard to reflection is engagement in “active and thoughtful consideration of what has come together in both research and development (including theoretical inputs, empirical findings, and subjective reactions) with the aim of producing new (theoretical) understanding” (McKenney & Reeves, 2012, p. 151).

In this study, the research questions are twofold: One is related to the intervention as a whole, including the success of the intervention (a graduate course for teaching and learning argumentation in science education) to achieve its intentions, that is, enhancing the teachers’ knowledge and skills related to the implementation of argumentation in science classrooms as well as new and refined ideas concerning the design. The second set of research questions are related to the exploration of a phenomenon- that is, the instructional practices the teachers engage in while implementing argumentation based lessons- that the intervention engenders. Thus, there is evaluation related to intervention in this study (see 3.4. Evaluation and Reflection, p.168), and there is evaluation related to the phenomenon the intervention helps to explicate (see Chapter 4, p.207). After the evaluation of each set of research questions, there is a reflection, provided as conclusion at each chapter, where I focused on the important aspects of intervention, and how the findings contribute to the development of theoretical and practical understanding on argumentation practices (see 3.5. Conclusion, p.203 and see 4.5. Discussion, p.262).

I should note that like the design and construction phase, the evaluation and reflection phase is not a one-shot phase, either. That is, evaluation took place in the early assessment of the design ideas to weigh the soundness and feasibility of the design. Soundness refers to how the theoretical ideas instantiated and they are applied in the design, while feasibility refers to the applicability of the design in regard to the resources available and accessibility of the participants. During the implementation of the design, evaluation took place to test how the design works in real context and at the end to what extent the intervention achieved its intended construction purposes. Reflection took place all through the EDR process.

2.3.4. Contributions of the educational design research in this study

Educational design research contributes to both theoretical understanding and practical applications. Theoretical understanding is the main input in educational design research because the researcher starts with a theory to design an intervention and frame the research process. It is also main output since the researcher advances the initial theoretical understanding by findings generated through the iterative process of educational design research. In general, educational design research conducted through interventions yields theoretical understanding that describes and explains certain phenomena (McKenney & Reeves, 2012). Therefore, the theoretical understanding emerging from educational design research conducted through intervention is descriptive and explanatory. The research described here is descriptive in terms of its attempt to describe how teachers develop pedagogy of argumentation and is explanatory because it contributes to explaining how an educational design can be used to advance the theory and practice of teachers in relation to argumentation. The level of contribution to the theoretical understanding is essentially at local level since only several iterations of one basic intervention are studied in just two classrooms. However, as the interventions mature and tested by a wide range manifestations across many different settings, the local theory generated in this research may develop to a higher level on a continuum.

Practical contribution of educational design research is the intervention itself, which is developed to be a solution to an identified problem in real practice, or the resulting product of the intervention, such as educational products, programs, processes or policies (McKenney & Reeves, 2012). In this study, the intervention is characterized by an educational program. Educational program developed in educational design research is usually a combination of educational products and processes. The argumentation in science teaching and learning course developed in this study is the educational program developed and refined. Educational products of the study are the participants' lesson plans and lesson videos as well as students' artefacts. The educational processes are described as the implementation of the course program and related audio- and video-records in addition to this dissertation. Besides the educational program, another practical contribution of this study is characterized by the educational field it contributes to. This study is active in the fields of learning and instruction as well as teacher development. The study contributes to the field of learning and instruction in the form of discovered specific learning strategies for argumentation-based science courses, instructional sequences developed by the researcher and the participating teachers, and learning materials produced by the participants. Finally, the educational design research described in this dissertation has made contributions to the field of teacher development through a specific kind of professional development program for in-service teachers and graduate students in science teaching programs in the form of a graduate course and argumentation specific learning resources.

2.4. Data Generation and Analysis

2.4.1. Data generation

As opposed to positivist understanding of data, which are in some sense lying around in a field, interpretive researchers believe that evidence being brought into existence at least first by the research focus then actions in the research setting (Schwartz-Shea & Yanow, 2012). Such understanding of data assumes that data have no prior ontological existence outside of the agenda of the research; they are generated in the process (Schwartz-Shea & Yanow, 2012). To generate data, qualitative researchers interact with the data source, therefore, by this interaction, researcher cannot act as an outside observer to what is being studied and so has an effect on the data generated (Garnham, 2008).

However, the generation of the data in the context of the study does not make the results unprocurable. Although the data yield results that are unique for the study, the results are open to inquiry. Moreover, they are comparable and might have consistencies with similar studies. The external readers, who might be other teacher educators and researchers, are going to decide how similar the conditions, or to which level the data are useful to predict the outcomes of other research by taking the conditions in this study into account. The researcher ensures the usefulness of the results by means of reflexivity, by clarifying the data sources, how the data were generated from these sources, how the data were interpreted within its social context, what the elements of the social context were, and by techniques which can increase the trustworthiness of the study.

Data sources, in this sense, may include the participants, documents, organizations, electronic media, and events (Garnham, 2008). In EDR, if the purpose is the development of a local instruction theory, Gravemeijer and Cobb (2006) suggest to video record all classroom sessions, conduct pre- and post-interviews, make copies of all artefacts, and assemble field notes as data sources. Before the enactment, the researcher may also investigate the standards in a similar project that have been used by other researchers if they are available. Researchers are also encouraged to audio record the regular meetings with the participants as well as other research group meetings in order to document the learning process along with a log of the interpretations, assumptions, and decisions throughout the process (Gravemeijer & Cobb, 2006).

Therefore, in this study,, I asked the participants to video record their classroom practices, I audio recorded their reflections on their classroom practices, I conducted pre- and post-interviews with the participants, audio-recorded all course sessions that took place in the university as a graduate course and meetings with my dissertation committee members, and I collected participants' written materials, such as their questions related to the article reviewed with regard to each week's topic in the course, their reflections related to their learning in each session of the course, their argumentation based lesson plans, their studies in the course, and their statement of argumentation in three instances during the course.

As regards to reflection papers, statement of argumentation assignment, and lesson plans, the participants were free to choose the format of presentation. Their written assignments were saved as word document or excel document with one to 3 pages.

Here, I should note that I conducted the interviews with some presuppositions with respect to the purpose and the structure of interviews in constructivist interpretive research. By contrast to the realist objectivist methodology, in this research I rested on the belief that there are multiple social realities, and the participants are interpreter of the events as much as I am. This ontology has some results reflected in the interviews: For example, during the interviews, I ascertained how individual participants experienced the course from their point of view – and is distilled through my understanding of their point of view- because different participants would emphasize different instances and experience different versions of the same event. Therefore, I asked questions such as "Which aspects of argumentation were effectively taught and learned during the course? Which activities and/or topics related to argumentation you find effective/ useful/ feasible and worth to learn and teach? What suggestions can you make for the next semester?" According to Schwartz-Shea and Yanow (2012), those differences are invaluable for the constructivist interpretive researcher, as they reflect different meanings that can be drawn about what is significant and meaningful about the event.

Moreover, I agree with Packer (2011) that an interview is always a joint production, "the researcher is always a partner in dialogue" (p.98). That is, the understandings derived from the interviews are co-generated through mutual interactions as we were in search for meaning and made our interpretations as legible as possible to each other (Schwartz-Shea & Yanow, 2012). Therefore, I had a general plan for the interview as suggested in semi-structured interviews, but, I did not follow a fixed order of questions or word these questions in the same way each time when interviewing with each person. Although I encouraged the interviewees to speak "in their own words" to obtain a first person account and allowed a great deal of independence in the way they answer, the length of their responses, and even the topics of discussion, I always kept in mind that our interaction is not a one-way relationship, and we are both influenced from our interpretations (Packer, 2011). Hence, in my writing, I provided my question as in the same way I asked during the interview, the context of the interview, and my account of what the interviewee said preceding the participants' answer.

2.4.2. Data analysis

Data sources- observing, interviewing and documents- are almost the same for all qualitative research. The research component which differentiates between qualitative inquiries is their data analysis method. In other words, the epistemological beliefs of the researcher depending on the research paradigm mostly influential in data analysis (Charmaz, 2000; Schwartz-Shea & Yanow, 2012).

Interpretive researchers, by studying teaching from all perspectives involving the viewpoints of those involved and classroom environment, try to provide a holistic view of the teaching conditions, interactions and processes. Therefore, the methodological approach is directed to generate rich information through qualitative data, and the presentation of the results become more narrative including the coding and categorising information but the cause –effect relationships are not established. In the research in line with interpretive paradigm, researcher is an active agent providing subjective interpretation of events and subjects as well as descriptions of observable behaviours, and should recognize that individuals may have different views of what is happening in the process of teaching or they may perceive the same environment differently. In the writing of results, therefore, the researcher should present factual information about the context and interactions (Schwartz-Shea & Yanow, 2012).

In this study, there are three approaches to data analysis:

Interpretive content analysis of classroom practices.

Classical content analysis has previously been defined as an objective and systematic study of texts for a quantitative measurement of the categories found in them (Kassarjian, 1977). Nonetheless, recorded human communications have also been the subject of the content analysis. For example, Babbie (2007) suggested the coding process of transcripts of human communications, and transforming data available to a standardized- quantitative form (Babbie, 2007; Ryan & Bernard, 2000). In a different way, Mayring (2000) applied the content analysis of human relations to a qualitative procedure. According to Mayring, content analysis of human communication can be done by means of an “empirical, methodological controlled analysis of texts within their context of communication, following content analytical rules and step by step models, without rash quantification” (Mayring, 2000, p. 2).

As a method of qualitative content analysis, interpretive content analysis (ICA) was proposed as an alternative to classical content analysis in terms of its approach to the coding and the assessment of the coding quality (Ahuvia, 2001). In ICA, generated codes are not considered to be parts in isolation apart from the rest of the text mainly because ICA take context more fully into account rather than being restricted by coding rules. In regard to the coding quality, ICA recognizes that having multiple coders is likely to be of higher quality in the coding, but argues that single coder is also sufficient. In other words, in contrast to the inter-rater reliability as an assessment criterion for the quality of coding, ICA substitutes “public justifiability” (Ahuvia, 2001). Public justifiability is achieved by including main texts, their coding, and a justification of coding to ensure that others reading the text be able to assess the quality of coding by themselves.

In this study, the transcripts of the participants' classroom practices are analysed by ICA (see 4.4.9. Instructional Strategies in Teaching practice, p.256). I preferred ICA because first, my analysis was towards understanding the instructional strategies used by teachers while implementing an argumentation based science lesson in their classrooms. The texts are not studied in terms of the participants' use of language, as in the discourse analysis, such as whether the question asked is a high quality or not, or whether arguments are constructed appropriately. Rather, my focus was on the interactions and which interactions of the teacher resulted with argumentation or its justification (see 4.4.1. Codes and categories for instructional strategies, p.224). This focus is not directed to understanding the different uses of language for the same purpose. Therefore, as in latent content analysis, meanings were important rather than the structure. Second, content analysis is an example of unobtrusive research, which studies social behaviour without affecting it (Babbie, 2007). In this study, I did not enter the classrooms to observe teachers in their implementation so I did not affect their in-classroom practices. Instead, teachers brought the video-records of their practices for me to analyse.

Baxter (1993) argued that the researchers who apply ICA often fail to report how they derived the coding categories and what their coding unit is. Moreover, she criticizes ICA in the assumption that meaning can be categorized (Baxter, 1993). This assumption leads researchers to ignore the emerging unique meanings, and to dismiss thick description for meaningful understanding. In order to overcome these difficulties associated with the trustworthiness of the data (see 2.5. Trustworthiness, p.44), specifically in conducting ICA, I explicated the theory guided this study (see 4.2. Literature review, p.211), explained my method for coding (see 4.3. Methodology, p.215), included example scripts to illustrate the coding, openly wrote my codes and my justification for the codes (see 4.4.1. Codes and categories for instructional strategies, p.224), and I provided a thick description of my understanding of argumentation and my background (see Chapter 5, p.269).

Interpretative phenomenological analysis of interviews and reflections.

Interpretative phenomenological analysis (IPA) is an inductive approach aimed at understanding in detail how individuals make sense of their personal experiences in relation to their social world (Reid, Flowers, & Larkin, 2005; Smith & Osborn, 2008). The purpose of analysis is not to test hypotheses and/or prior assumptions, but rather to explore the meanings that individuals assign to their experiences (Reid, Flowers, & Larkin, 2005). Researcher achieves the purpose of such analysis first by focusing on participants' description of their experiences (phenomenology perspective) and second by making sense of these in relation to a wider social, cultural, and theoretical contexts (interpretative perspective) (Larkin, Watts, & Clifton, 2006).

In IPA, after transcribing data, researcher intensively works on the text in order to code it for insights into participants' experience and perspective. As the analysis develops, codes are catalogued to bring recurring patterns of meaning or themes together in order to identify the important matters for the participant as well as provide meanings of those matters in a larger theoretical framework (Storey, 2007).

IPA usually involves in depth analysis of individual cases, and results are discussed in relation to the literature (Smith, 2004). The results are presented with examples from data to ensure transparency, which is the degree of details about the context and process along with adequate interpretation on data. In addition, plausibility to participants, co-analysts, supervisors, and general readers; transferability to other contexts; as well as reflexivity of the researcher are crucial to the trustworthiness due to the interpretative and collaborative nature of the IPA interview and data analysis (Reid, Flowers, & Larkin, 2005).

In this study, I performed IPA in analysing interviews with the participants and their reflection papers regarding each week of the course to capture and explore their perspective and experiences regarding argumentation and the designed graduate course on argumentation. I conducted semi-structured interviews with the participants, my advisors, and the participant-observer before and after the course, and I drew inferences based on the codes and subsequent themes derived from data from the interviews. In overall, the results provided me insight into different stakeholders' understanding and experiences regarding the design, and how they are interpreted in the framework of transformational teacher learning and argumentation theory (see 3.4. Evaluation and Reflection, p.168).

Personal narrative analysis.

Narrative analysis is the name given for "a variety of orientations to interpreting varieties of discourse, including narrative texts" in light of a theory for understanding, and by integrating variety of data from different sources (Daiute & Lightfoot, 2004, p. xi). By means of narrative analysis, researchers systematically attempt to make sense of particular types of personal experiences (Bamberg, 2012).

Researchers can inquire by narrative analysis in order to have a holistic interpretation of phenomena (Packer, 2011), issues or lives that are the subject of interest; have an examination of social histories that may have an influence on person's or society's identity and development; have unique insights into a wide range of forces that sequence and consequence relations between individuals and society; or have more integration of values into the research (Daiute & Lightfoot, 2004). Recently, auto ethnographers have found that narrative discourse is an excellent context in writing their own narratives and relating them to their research materials (Riessman, 2004).

Narrative analysis involves collecting evidences of personal experiences in the form of field texts, retelling these experiences based on, for example, interactions, continuity, and contexts; rewriting them in chronological order; and incorporating the setting and social place of the person (Creswell, 2007).

In this study, I applied auto ethnography in writing of my personal experiences regarding the planning for, implementation, and evaluation of the design. Auto ethnography required me to analyse my background in argumentation and teaching, and to write a reflexive and chronological account of my experiences. In this process, I conducted narrative analysis on the data in the form of texts, such as my journal articles and conference proceedings, to make sense of my experiences in the past (see Chapter 5, p.269). Narrative analysis is essentially subjective because in this process I wrote about my experiences and the influence of my past experiences was not inevitable. However, I clearly divulge all my presuppositions, my theoretical orientation, my background, and my perspective to ensure the credibility of my interpretations.

2.5. Trustworthiness

Interpretive inquiry is oriented towards understanding participants' meaning-making in naturalistic research settings without controls to the 'bias' (see 2.5.4. About bias in interpretive research, p.46). Moreover, interpretive researchers are aware that their presence in the research setting constitutes the major instrument for accessing and making sense of data for understanding meaning-making at individual and community levels. This logic of inquiry in interpretive research makes quality assessment criteria and associated practices related to the trustworthiness quite different than the measures in positivistic research. In other words, the quality standards of positivistic inquiry, such as objectivity, (statistical) generalizability, and reliability, are ill-suited to interpretive research due to the presuppositions regarding the multiplicity of interpretations and the instability of social world in interpretive research (Creswell & Miller, 2000; Yardley, 2008).

From interpretive perspective, the trustworthiness of researcher's knowledge claims is assessed in terms of the contributions to the quality of research (Schwartz-Shea & Yanow, 2012). The presence of the following criteria in interpretive research constitutes its trustworthiness: reflexivity, member-checking, and thick description (Gravemeijer & Cobb, 2006; McKenney & Reeves, 2012; Schwartz-Shea & Yanow, 2012). Researcher is expected to report on these quality strategies and make her embodied self as explicit and transparent as possible within the documents to ensure trustworthiness.

2.5.1. Reflexivity

Reflexivity is a crucial component of interpretive research (see 2.2.2. Reflexivity, p.26) because positioning themselves in research setting, researchers convey their background and identity, which inform their interpretation, into the research process. Thus, reflexivity ensures the transparency of the presence of the researcher and her claims, thereby increases the trustworthiness in a significant way (Schwartz-Shea & Yanow, 2012).

In this study, I organized my writing to include my reflexivity all through the research process. Specifically, I wrote about what prompted my interest in the topic of investigation, and what I personally stand to gain from the study in detail. My background related to this research and my orientation to philosophy of education are also emphasized in corresponding chapters (see Chapter 1, p.1 and Chapter 5, p.269).

2.5.2. Member-checking

Interpretive researchers assume that meaning is co-constructed, and so there are multiple meanings that could be equally valuable. In this perspective, data are co-generated by researcher and participants on the setting and these data may be interpreted in a variety of ways. Therefore, the inclusion of member-checking, that is sending or bringing data and interpretations back to participants for their feedback, comments, and interpretations, increases the credibility of interpretive research (Schwartz-Shea & Yanow, 2012; Schwartz-Shea, 2006).

In this study, after transcribing the interviews conducted with participants, I send the transcripts in Turkish and English to them via e-mail. I asked them to read through the transcripts and reply to me via mail with any comments related to their interview. All participants reviewed the transcripts and notified me about the changes- if any, such as shifts in the meaning in translated documents. Before starting coding process, I revised the transcripts based on their feedback. Moreover, I brought segments of this research manuscript reporting on the parts of the graduate course in which they were involved to the participants in order to see whether my understanding of the events are similar to their perspective. Face-to-face conversations with participants allowed me immediately correct any misunderstanding and have on-time feedback.

2.5.3. Thick description

According to Schwartz-Shea and Yanow (2012), since sense-making is always dependent on the context, interpretive researchers should concern with contextuality- also referred to as ecological validity (e.g. Gravemeijer & Cobb, 2006) or transferability (e.g. McKenney & Reeves, 2012) - instead of generalizability. To be precise, they argue that for others to assess the relevance of the research to their own settings, and the extent to which knowledge claims fit their cases and purposes, researcher should describe the context in sufficiently thick ways (Schwartz-Shea & Yanow, 2012). From educational design research perspective, for example, Gravemeijer and Cobb (2006) emphasize contextuality and thick description with regard to "what happened in the design experiment" so that others can decide to which degree the results allow for adaptation to other situations (p.77).

However, researchers should not expect to agree with all conclusions in this study when they read through or apply the design into their settings. In this study, I reported all research process as transparent and thick as possible so that the theoretical insights and practical processes can be traced and virtually replicated. Nevertheless, other researchers may have different experiences and may interpret those experiences in completely different ways. This should be seen normal for interpretive studies as well as valuable because it provides an experiential basis for discussion (Gravemeijer & Cobb, 2006; Schwartz-Shea & Yanow, 2012).

Further, I applied two additional criteria suggested by Creswell (2007) to enhance the trustworthiness:

- Prolonged engagement; since this research is an example of an educational design research, I involved in the development and implementation of the design for two semesters (26 weeks). I was in the field and acted not just as a persistent observer but also facilitator because educational design research develops theory in practice. Therefore, in this study, prolonged engagement is assured.
- Triangulation; there were multiple data sources in this study that I generated evidence for my interpretations (see 2.4. Data generation and analysis, p.38). I scheduled meetings with my advisor and participant observer to discuss their perspective for corroborating evidence from different sources. Moreover, I discussed my codes and interpretations with my dissertation committee members to have an awareness of alternative meanings and to check the soundness of my knowledge claims during analysis.

2.5.4. About bias in interpretive research

Interpretive research is a naturalistic inquiry into people's lives and their meaning-making. The purpose is not to test a hypothesis or a theory but rather, along with educational design research, contribute to theory and practice by understanding of human meaning-making in context. To do this, interpretive research does not attempt to include any sorts of control. Therefore, research designs that try to eliminate researcher bias or control for threats to research do not fit to interpretive research methodology (Schwartz-Shea & Yanow, 2012). In contrast, in interpretive methodology, the researcher is the primary instrument of data generation and interpretation, so her presence deserves attention and analysis. This does not mean that the assessment of the trustworthiness is ignored, but the assessment should be according to contextual and theoretical factors in the research setting (Schwartz-Shea, 2006).

I agree with Schwartz-Shea and Yanow (2012) that researchers can be aware of the bias that they bring into the research. They argue that "To presume that humans cannot be aware of their biases is to reject human consciousness- the possibility of self-awareness and reflexivity- and human capacity for learning" (Schwartz-Shea & Yanow, 2012, p. x). In interpretive research, researcher does not undermine the influence of her presence in the research setting, rather acknowledges that by reflexivity (see 2.2.2. Reflexivity, p.26), along with her identity (Schwartz-Shea & Yanow, 2012).

In sum, neither of the bias can be avoided or controlled for in interpretive research. Instead, researcher aims for their acknowledgement, along with her engagement in the research process and analyses. To achieve this, reflexivity is emphasized in interpretive research (Schwartz-Shea & Yanow, 2012).

2.6. Summary

In overall, in this chapter, I explicated my research paradigm, my research method and design, as well as my criteria for the quality of the research with theoretical basis. The research paradigm that informs this study was described as constructivist interpretive research. The research methods were identified as interpretive qualitative approaches and auto ethnography. The research design was modelled as a generic model of educational design research. The quality criteria and how I addressed them in this study were also explicated in the trustworthiness.

To draw an outline, this study involves mainly three parts informed by the research tradition and its associated presuppositions: the design of a graduate course by educational design research with its theoretical insights and practical implications, the contribution to the argumentation theory in science education by introducing instructional strategies in argumentation-based science classes by the participants, and auto ethnographic inquiry into my experiences in the research process as facilitator and researcher. Each part involves its own introduction, theoretical background, methodology, results, conclusions and implications.

CHAPTER 3

THE DEVELOPMENT OF EDUCATIONAL DESIGN: A GRADUATE COURSE ON ARGUMENTATION IN SCIENCE TEACHING AND LEARNING

This chapter describes the development, implementation and evaluation of a graduate course aimed at professional development of participants on argumentation in science teaching and learning. Educational design research methodology was applied to achieve the tasks. Depending on this methodology, this chapter essentially is composed of three parts: (1) analysis and exploration; (2) design and construction, and (3) evaluation and reflection. Within this perspective, the first part involves the identification of the problem, initial perception of the problem by the stakeholders and causes of the problem as well as how other researchers have viewed and solved similar problems in terms of the contributions made by their studies into the current research. In the second part, the solutions to the problem situation were mapped and a deliberative generative process of constructing an educational design on argumentation in science teaching and learning was described. . Evaluation and reflection part was the log and interpretation of the empirical testing of the design with participants and active- reflexive consideration of the empirical findings along with theoretical inputs and subjective reflections.

3.1. Purpose of the chapter

The purpose of this chapter is to describe the development of a graduate course, which is aimed at improving science teachers' and graduate students' knowledge and pedagogy related to argumentation so that they could be able to incorporate argumentation into their teaching.

Yet, when implementing a new learning approach, material or curriculum, teachers often tend to transpose innovative approaches into a more familiar, conventional way of instruction (Zohar, 2006). On the contrary, my aim for this course was to study with the participants in such a way that they become educated and conscious in bringing argumentation practices into their classes. Therefore, I designed the course based on the successful models of teacher professional development programs and in multi-cycles so that the course content and implementation foster the participants' abilities to teach science in a way that would develop students' autonomous argumentation in scientific issues.

3.1.1. Research Question

The research question with subsidiary questions regarding the development of a graduate course, which is designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning, are:

1. How does a graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning contribute to science teachers' knowledge related to argumentation?
    a. What are the elements of a graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning?
    b. How do science teachers' understanding of argumentation change over the graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning?

For input in these areas, the experiences and reflections of participants during theory building were examined. The theoretical background related to teacher' learning, professional development frameworks, and science teacher education on argumentation was built in advance to design and construction of the course.

3.2. Analysis and exploration: Understanding argumentation in science education and conceptualizing the research

The main purpose of the analysis and exploration part was to understand the theoretical constructs, identifying the problem statements, and seeking for solutions. In this respect, in the analysis, I provided the identification of the problem in the literature and relevant theoretical background, statement of the problem, research questions, and significance of the study as well as participants and their understanding of the problem. The exploration part involves the investigation of other similar research efforts and the contribution of them into the solution of the problem.

3.2.1. Argumentation

Given that the purpose of this study is to explore how science teachers develop pedagogy of argumentation, it would not be out of place to begin with the distinction between the constructs, ‘argument’ and ‘argumentation’. Argument is not synonymous with argumentation. The former refers to the content or substance of the argument comprised of claims, data, warrants, and supporting evidence, while the latter refers to the process of arguing (Osborne, Erduran, & Simon, 2004).

In the educational literature, various forms of argument are presented depending on how it is approached. In one approach, argument is regarded from two perspectives: (i) “rhetorical” (Kuhn, 1991) or “didactic” (Boulter & Gilbert, 1995) and (ii) “dialogical” or “multi voiced” (Driver, Newton, & Osborne, 2000). Within the former perspective, argument is described in the Oxford English Dictionary (Oxford Dictionaries, 2014) as “advancing a reason for or against a proposition or course of action.” The underlying goal of the argument in this sense is to persuade the receiver of the strength of the case being conveyed. Examples of such arguments are common in science lessons where a teacher provides a scientific explanation to a class or to a group of students with the intent of helping them to see it as reasonable (Driver, Newton, & Osborne, 2000). The latter approach to argument is based on the assumption that constructing an argument involves taking into consideration alternative positions. Thus, different perspectives are examined and the purpose is to reach an agreement on acceptable claims or courses of action (Driver, Newton, & Osborne, 2000).

Van Eemeren et al. (1996), on the other hand, state that there are three generally recognised forms of argument: analytical, rhetorical and dialectical. Analytical arguments take place within the domain of formal reasoning, which is concerned with the logical structure of arguments – whether a conclusion follows logically from given premises. However, scholars maintain that formal logic not only falls short in studies seeking to describe the argumentation process in science (Walton, 1999), but is also irrelevant for inclusion in science teaching (Driver, Newton, & Osborne, 2000). Rhetorical and dialectical forms of arguments fall within the domain of informal reasoning. An argument is said to be rhetorical in form when there are monologues in which an orator employs discursive techniques with the aim of persuading an audience. In contrast, an argument is considered to be dialectical in form when dialogues involving two or more discussants are existent. Consequently, argumentation in informal reasoning exists in two forms: individualistic or social (Kolsto & Ratcliffe, 2008). In the individualistic approach, an individual formulates a point of view, whereas in the social approach of argument, there is generally a dispute between two or more people. In other words, argument can be an individual endeavour carried out by means of thinking and writing, or a negotiated social act (Akkus, Gunel, & Hand, 2007), in which co-operating individuals strive to justify their actions, adjusting their intentions and interpretations towards this end (Patronis, Potari,

& Spiliotopoulou, 1999). It can be claimed that primarily all argumentations are basically social in nature as they expect an audience in most cases (Kolsto & Ratcliffe, 2008).

Argumentation has a central place in many of the endeavours carried out in science education. Within the scope of science, argumentation takes place in such conducts as developing simplifications, such as taxonomies, laws and mathematical formulae, in establishing cause-effect relationships, and in presenting evidence from observation and experiments (Newton, Driver, & Osborne, 1999). From this perspective, it is an essential component of decision making, in which scientific and technological knowledge comes into play (Patronis, Potari, & Spiliotopoulou, 1999). It is also vital in data analysis, manuscripts with persuasive explanations, and dialogues (Clark & Sampson, 2007) as argumentation in science is regarded as a “logical discourse whose goal is to tease out the relationship between ideas and evidence” (Duschl, Schweingruber, & Shouse, 2007, p. 33). According to Siegel (1995), the goal of argumentation is to resolve questions, issues or disputes. On the other hand, Billig (1996) postulates that argumentation can be regarded as an activity with the aim of using any persuasion technique possible. Similarly, van Eemeren, et al. (1996) asserts that “Argumentation is a verbal and social activity of reason aimed at increasing (or decreasing) the acceptability of a controversial standpoint for the listener or reader, by putting forward a constellation of propositions intended to justify (or refute) the standpoint before rational judge” (p. 5). Another view is put forward by Binkley (1995), who described argumentation as “constructing a reckoning” (p.137). Binkley viewed the process of argumentation as a constructive process by which thoughts are organized within an abstract structure of premises and conclusions. This view assumes that a structural argument organizes thoughts in a certain way (Driver, Newton, & Osborne, 2000).

Argumentation theory has been developing for several decades and related studies are conducted in various disciplines, namely developmental psychology, including the distributed cognition perspective; philosophy, such as the theory of communicative action; language sciences; and science studies, i.e. history, philosophy and sociology of science (Erduran & Jiménez-Aleixandre, 2012).

A significant contribution to the field of argumentation was made by Toulmin (1958) with his book entitled, *The Uses of Argument*. Different from the studies in the traditional field of logic, Toulmin’s study focused on exploring ways people argue in natural settings (Driver, Newton, & Osborne, 2000). He analysed arguments in a variety of contexts, including legal contexts and arguments in science. As such, it was the first study in its field to challenge the 'truth' seeking role of argument; it focused on the rhetorical elements of argumentation (Duschl & Osborne, 2002). Based on the findings of his study, Toulmin presented a model that presents the constitutive elements of argumentation and the functional relationships among them. This model has not lost any weight in its influence. On the contrary, in recent years, science educators have increasingly begun to resort to Toulmin's model in their attempt to describe students' arguments (Erduran, Simon, & Osborne, 2004; Kelly, Druker, & Chen, 1998).

In essence, Toulmin's model describes the components inherent in reasoning. The main components as identified by Toulmin (1958) are as follows: Claim (C) is an assertion that someone makes and whose merits we are seeking to establish; Data (D) are "facts we appeal to as the foundation for the claim" (p.90);Warrants (W) are "bridge-like statements" (p.98), which are in the form of general rules, principles, etc., that are proposed to justify the connections between the data and the claim; and Backing (B) "for warrants can be expressed in the form of categorical statements of fact as well as can the data appealed to in direct support of our conclusions" (p.98). Toulmin identified two additional features in more complex arguments: Qualifier (Q) is "some explicit reference to the degree of force which our data confer on our claim in virtue of our warrant" (p. 93); and Rebuttal (R) indicates "circumstances in which the general authority of the warrant would have to be set aside" (p. 94). Thus, according to Toulmin's model, the structure of an argument is based on an interconnected set of claims, data supporting the claims, warrants that build a connection between the data and the claims, backings that reinforce the warrants, and finally, rebuttals which refer to the circumstances where the claims would not be valid (Erduran, Simon, & Osborne, 2004).

Of these elements inherent in an argument, the rebuttal can be considered to be of crucial importance, not undermining that of the other components, because the presence of a rebuttal is a significant indicator of the quality of argumentation and without rebuttals, individuals engaged in argumentation remain epistemically unchallenged (Erduran, Simon, & Osborne, 2004). A rebuttal and how it provides counterarguments enable participants holding opposing views to evaluate the validity and strength of the argument in question. That is, without rebuttals, arguments do not yield any change in viewpoint or the evaluation of the quality of an argument. Thus, arguments with rebuttals are believed to be a vital component of better quality arguments and display a higher level of capability with argumentation (Erduran, Simon, & Osborne, 2004).

However, according to Toulmin, the quality of an argument cannot be judged solely by its form. The content and context of an argument, which refers to the evaluation of arguments as they occur in practice, are also of great importance in identifying the data, warrants, and backings in an argument. It is for this reason that Toulmin introduced the idea of argumentation field. The argumentation field frames or specifies the content for the argument. Thus, both field-dependent and field-independent elements form the content of an argument (Duschl, 2008). As of this influential work of Toulmin in 1958, the notion that 'a good argument' is relative to the context in which it takes place has gained increasingly wide acceptance (Newton, Driver, & Osborne, 1999).

Moreover, Toulmin's model has been employed as a methodological tool in studies where a wide range of school subjects is analysed (Erduran, Simon, & Osborne, 2004). Among these studies, science education research has utilized Toulmin's model as a heuristic for assessing student work (Jiménez-Aleixandre, Rodriguez, & Duschl, 2000) as well as for supporting student learning (Duschl, Ellenbogen, & Erduran, 1999). One other purpose for which Toulmin's perspective on argument was employed was in the area of examining argument quality in science (Bell & Linn, 2000; Erduran, Simon, & Osborne, 2004; Jiménez-Aleixandre, Rodriguez, & Duschl, 2000; Kelly & Chen, 1999; Sampson & Clark, 2008). More specifically, researchers who employed Toulmin's model in their studies have significantly shed light on the ways that students structure arguments and the nature of the justification they use to support their ideas (Sampson & Clark, 2008).

One of the earlier attempts using Toulmin's layout of argument is a study by Kelly, Druker and Chen (1998). The objectives of this study were twofold, the first of which was to use this model as a research methodology to examine students' discourse and reasoning in argumentation. With this study, they offered a rationale for looking at students' arguments, applied this methodology to a data set, and suggested possibilities and limitations to this type of analysis. Their second objective was to reveal the reasoning processes students utilized while solving electricity performance assessments. To achieve this objective, they paid particular attention to examining both the justifications students used to support their claims and the conditions that led to these justifications. That is, they focused on how and under what conditions students justified their claims related to electric circuits while trying to solve a performance assessment task. The participants of their study were students from a physics class in which there were 20 students. The students carried out the class work collaboratively in teams over the course of 2-4 weeks. A modified version of Toulmin's model was used in analysing the student dyads. The student discourse transcriptions were initially analysed by means of Toulmin's original set of argument categories and additions (e.g. challenge). In this initial stage, they strove to base their methods on the data of student talk and to modify their initial argument scheme as required. This established a foundation upon which the discourse analysis method to be used was based. Despite the fact that a great variability of patterns was found in the students' arguments, results showed that the task could be completed without justifying all arguments. Thus, it cannot be proven that lack of knowledge leads to more justified arguments. It was deduced that the lack of justification for arguments could have derived from assuming that the receiver of the argument possesses common knowledge with the person making the argument. Hence, the hypothesis is that there is less likelihood of providing justifications for arguments when the receiver of the argument is assumed to have common knowledge (Kelly, Druker, & Chen, 1998).

Another study in which Toulmin's model was employed and is worth mentioning is one that was a part of the project entitled "Enhancing the Quality of Argument in School Science", which was conducted between 1999 and 2002 and supported by the Economic and Social Research Council in the United Kingdom. Erduran, Simon and Osborne (2004) worked in collaboration with middle-school science teachers to develop models of instructional activities with the aim of integrating argumentation into instruction. Subsequently, using Toulmin's model, they examined the argumentation in the whole-class discussions between teachers and students, and that occurring in small-group discussions among students. Specifically, two methodological approaches were employed to analyse the discourse in the argumentation. The first approach sought to quantify the arguments and provide some qualitative comparisons between arguments generated in different lessons. The second approach was based on utilizing TAP as an indicator to define the quality of argumentation based on the presence and nature of the rebuttals that are voiced among students. Results showed that the largest number of arguments emerged from Level 2 students both at the beginning and end of the year (38% and 30%, respectively). The analysis also yielded comparative qualitative data regarding teachers' specific discourse practices. In addition, the scheme that was devised to assess argumentation in terms of levels illustrated the quality of opposition or rebuttals in the student discussions conducted in small groups. Finally, the use of TAP was extended with the aim of judging enhanced quality of argumentation (Erduran, Simon, & Osborne, 2004).

However, Toulmin's model is not without limitations. Despite the influential impact of Toulmin's model and its widespread use in studies, it is limited in some ways. First of all, although it can be used to evaluate the structure of arguments, it does not lead to conclusions regarding their accuracy. It has been pointed out, by Toulmin himself too, that, judgments in relation to the correctness of the argument necessitate the inclusion of subject knowledge into the arguments to be examined (Driver, Newton, & Osborne, 2000). Another limitation is based on the difficulty of clarifying what counts as claim, data, warrant, and backing (Erduran, Simon, & Osborne, 2004). Furthermore, Toulmin's model presents argumentation in a decontextualized way. There are interactions in arguments as a speech event, and argumentation is a discourse phenomenon that is affected by the linguistic and situational contexts in which the specific argument takes place. However, Toulmin’s model takes into consideration neither the interactional patterns nor the linguistic and situational contexts (Driver, Newton, & Osborne, 2000). Real-life arguments need to be examined by taking these factors into account, and therefore, some interpretation of the text is necessary. One other limitation concerns illustrations and graphics. In Toulmin’s model, illustrations and graphics assume a supplementary role. However, currently they are regarded as central communicative features of texts (Driver, Newton, & Osborne, 2000). In addition, while using Toulmin’s model or framework of argument, a researcher will most of the time be influenced by his/her personal perspectives in deciding what should be regarded as a warrant, claim, or data (Sampson & Clark, 2008). Moreover, the majority of the research conducted using Toulmin’s argument framework does not focus on field-specific features of an argument. Thus, it is unfortunate that very little is known about how well arguments constructed by students conform to the criteria shared by the scientific community for judging quality (Sampson & Clark, 2008). Finally, the appropriate level of detail necessary to support the reasons given to make an argument is unclear in Toulmin’s model since it employs very general and broad categories (e.g., data, warrants, backings, rebuttals, qualifiers, conclusions) to characterize arguments (Duschl, 2008).

As opposed to Toulmin’s framework, which concentrates on the components of an argument, Walton’s schemes rests on various types of arguments (Erduran & Jiménez-Aleixandre, 2012). Argumentation schemes focusing on presumptive reasoning dwell on the evidence and premises a person uses in his/her arguments and lead the respondent to examine the premises posed by the other (Walton, 1999). Presumptive reasoning occur during dialectical argumentative exchanges, such as those which occur during science investigations carried out collaboratively by small groups, within assessment conversations (Jiménez-Aleixandre, Rodriguez, & Duschl, 2000) and asynchronous computer supported communication environments (Bell & Linn, 2000) where the discourse is focused on one or more advocates' positions. The use of Walton's schema in analysing small group discourse (Duschl, Ellenbogen, & Erduran, 1999) has suggested that presumptive reasoning can be employed as a framework to examine argumentation by students (Duschl & Osborne, 2002).

Presumptive reasoning entails a conclusion in the form of an inference; that is, the conclusion is based on a guess or presumption, which suggests that it is tentative and may change when there is new information available (Walton, 1999). Yet, this temporary nature of presumptive reasoning does not mean that it is not plausible. Presumptive reasoning is still based on the idea of collecting evidence, but in a different manner. Evidence in presumptive reasoning is collected while moving forward in the process of discussing an issue or a process of collecting data, or both. Hence, it is dynamic in nature and evidence may go one way or another. That is, acceptance of a claim can be contra-indicated, resulting in its "defeat", or the new evidence provided may yield additional reasons for its acceptance. Consequently, presumptive arguments can have some value as rational arguments in support of claims (Walton, 2001).

Walton made a significant contribution to the domain of argumentation with the concept “new dialect”. The new dialectic is primarily concerned with the most common kinds of everyday arguments, and is based on presumptive reasoning rather than deductive or inductive logic. The new dialectic has numerous common features with the old dialectic of Plato and Aristotle. However, it is also has various uncommon features. In Walton’s new dialectic, argumentation is analysed and evaluated based on the purpose of the type of dialogue carried out within a conversational exchange. In evaluating the plausibility and rationality of a type of dialogue, the dialogue needs to be measured against its own standards. From this viewpoint arose the Walton’s argumentation theory, which was based on terms of acceptance (commitment) instead of belief or knowledge; that is, an argument was rational so long as it was accepted. Unlike the deductive logic, which assumes an impersonal framework, Walton’s argumentation theory viewed an argument as a dialogue exchange between two parties reasoning together (Walton, 1999).

The argumentation schemes of Walton (1999) are forms of argument or “structures of inference” that facilitate identifying and evaluating common types of argumentation in everyday discourse, some of the best examples of which are argument from analogy, ad hominem argument, argument from ignorance, argument from sign, argument from consequences, appeal to popular opinion, appeal to pity, and appeal to expert opinion. These different types of arguments seem to have recognizable structures and those fitting the schemes appear to be neither deductive nor inductive (Walton, 2001). The argumentation scheme and the matching critical questions are used to evaluate a given argument in a particular case, in relation to a context of dialogue in which the argument occurred (Walton, 1999). The findings are presented as tentative hypotheses with the aim of clarifying the discussion and proceeding constructively and openly (Walton, 2001). The new dialectic necessitates taking into consideration different contexts of the arguments used, such as the type of dialogue, the stage of a discussion, the commitments of the discussants, and other factors that may be specific to a certain case of argumentation in which the speakers are collaboratively reasoning towards a purpose. Furthermore, in the new dialectic, judging how an argument was used in a given case is also a contextual issue. Consequently, the context of use of the argument is of crucial importance in providing and acting as evidence while judging an argument (Walton, 1999).

The project *Science Education through Portfolio Instruction and Assessment* (SEPIA) was a study employed Walton's schemes (Duschl, 2008). The primary focus of the study was on epistemic goals as learning outcomes. The participants in the study consisted of 17 triads of middle school students. Data were obtained by means of 45–60 minute long structured interviews with the participants, who were assigned to review and then provide constructive feedback for the improvement of a science fair project. Walton's argumentation schemes for presumptive reasoning were employed with the rationale that in the case where the goal was to improve students' scientific reasoning, a more detailed framework was needed to monitor and guide how students were employing evidence in the construction of their arguments. The Walton schemes for presumptive reasoning provided such details and adequately fit the discourse structures and reasoning sequences of the group interview (Duschl, 2008). Eight of the 25 argumentation schemes proposed by Walton were selected for the analysis of the reasoning units. The reasoning sequence refers to the conversation that takes place between group members while debating or arguing for or against a specific course of action or claim. The analysis of the data yielded two distinct patterns. First, the SEPIA groups, as compared to the non-SEPIA groups, had engaged in a higher frequency of dialogic argumentation schemes in all categories of presumptive reasoning. Secondly, the rank order of argumentation schemes displayed by SEPIA and non-SEPIA groups (i.e., the average number of arguments per student group per scheme) were the same (Duschl, Ellenbogen, & Erduran, 1999). The interpretation of the frequency data indicated that the curriculum, instruction, and assessment models that guided the design of SEPIA units promoted presumptive reasoning discourse, particularly in two areas: e.g. requests for information and inferences (Duschl, 2008; Duschl, Ellenbogen, & Erduran, 1999).

It can be concluded from the results of this study that students employ a pattern of argumentation; and that asking students to evaluate and then give advice on how to improve a product reveals the evidence, premises, the beliefs and assumptions regarding the issue. The high correlation reported by the study can also regarded as evidence that middle school children have the cognitive and social competence to engage in presumptive reasoning regarding science topics (Duschl, 2008). The researchers reported that the wide range of argumentation schemes employed by students suggested that the argumentative practices of students in real life reflect a mixture of analytical, dialectical and rhetorical devices (Duschl, 2008). Moreover, the data suggested that a developmental phase of argumentation evolve from the dialectical structures or patterns student employ naturally towards the analytical ones that scientists employ. Finally, the analysis demonstrated that individuals bring much more to argumentation than are identified by specific analytical schemes (Duschl, Ellenbogen, & Erduran, 1999).

Another study in which Walton's schemes were employed was conducted by Ozdem, Ertepinar, Cakiroglu, and Erduran in 2013. The aim of this study was to investigate the kinds of argumentation schemes generated by pre-service elementary science teachers (PSTs) as they perform inquiry-oriented laboratory tasks, and to explore how argumentation schemes vary by task as well as by experimentation and discussion sessions. The design framework was based on the model of argumentative and scientific inquiry, which necessitated the inquiry of scientific topics by groups of participants through experimentation and critical discussion sessions. The participants of the study were 35 PSTs, who were to teach science in middle school to students from grade six to grade eight. The data were collected by means of video- and audio-recordings of the discussions made by PSTs in six inquiry-oriented laboratory sessions.

For the analysis of data, pre-determined argumentation schemes by Walton were used. The results illustrated that PSTs applied varied premises rather than only observations or reliable sources to ground their claims or to argue for a case or an action. It is also worthy to note that the construction and evaluation of scientific knowledge claims resulted in different numbers and kinds of arguments. Consequently, the results of this study suggest that designing inquiry-oriented laboratory environments, which are enriched with critical discussion, provides discourse opportunities that can support argumentation. Moreover, PSTs can be encouraged to support and promote argumentation in their future science classrooms if they engage in argumentation integrated instructional strategies. The use of Walton's framework reveals patterns in the argumentation of participants by eliciting the grounds on which the claims are based. By means of this analysis framework, researchers can understand the premises in the arguments and the criteria used to evaluate knowledge claims. Moreover, the categorization of arguments inherently acknowledges the diversity of arguments that are of relevance to science teaching in different pedagogical contexts such as discussions and laboratory investigations (Ozdem, Ertepinar, Cakiroglu, & Erduran, 2013).

Another theory of argumentation is called as hypothetico-predictive argumentation (Lawson, 2003). According to Lawson (2003), hypothetico-predictive arguments are employed to test causal claims, which are either perceptible or imperceptible. As stated by this theory, when scientists look into causal relationships, they generate and then test their alternative hypotheses through cycles of hypothetico-predictive argumentation. The main point of this theory is that the research process is not complete until convincing hypothetico-predictive arguments have been generated in relation to the reasonable alternative hypotheses. Thus, the primary concern of this view of scientific argumentation is to discover which of the alternative explanations or claims proposed for a scientific problem is correct and which are incorrect. This means that a claim is initially considered as a tentative explanation, which may be correct or incorrect. Hence, it needs to be tested. To do so, certain predictions are made and evidence is gathered. Once a sound or 'correct' conclusion is reached, another process of argumentation begins so as to convince or illustrate the soundness of the conclusion (Lawson, 2003).

The very first traces of the ability to construct and comprehend hypothetico-predictive arguments at the highest level are found in the pre-verbal reasoning of the sensory-motor child and the gradual internalization of verbalized arguments which include nominal, categorical, causal and theoretical propositions (Lawson, 2003). It can be concluded, therefore, that hypothetico-predictive arguments are used during concept construction and conceptual change since the ability to construct and comprehend hypothetico-predictive argument, which is an aspect of procedural knowledge is necessary for the construction of conceptual knowledge, which is an aspect of declarative knowledge (Lawson, 2003).

Lawson (2003) states that successful hypothetico-predictive reasoning entails reflective thought and, thus, may require considerable time. The implication of this for the classroom setting is that teachers need to spare sufficient time for student thinking. Also, they should be open to unusual and unexpected ideas. The generation and debate of hypothetico-predictive arguments in science instruction improve students' conceptual understanding as well as their argumentative or reasoning skills (Lawson, 2003). To summarize, the first goal is to provide students with sufficient time and sufficient reasoning skill and reflectivity for conceptual acquisition and to conceptual change. The second goal is increase students' awareness in constructing and using such arguments. Towards this end, teachers need to engage students in verbal and written discourse and to enable them to reflect on the arguments and science concepts being taught (Lawson, 2003).

3.2.2. Argumentation in science education

In science education, over the past decade, argumentation has been a prominent concern in research, and a common goal in science curriculum in many countries (Lee, Wu, & Tsai, 2009; Ozdem, Erduran, & Park, 2011; S-TEAM, 2010). Argumentation is considered to be a key element of the "scientific culture" and an indispensable part of the science education in schools (Jiménez-Aleixandre & Erduran, 2008; Tiberghien, 2008). Therefore, it should be taught and learned in the science classroom as part of the learning of scientific inquiry and scientific literacy (Duschl & Osborne, 2002; Erduran, Simon, & Osborne, 2004; Jiménez-Aleixandre, Rodriguez, & Duschl, 2000; Zohar & Nemet, 2002), helping to promote students' scientific reasoning and conceptual understandings (Lawson, 2010; Yeşiloğlu, 2007; Zhou, 2010) as well as support students enculturation into the practices of scientific culture (Dawson & Venville, 2010; Jiménez-Aleixandre & Erduran, 2008).

In their influential article, entitled "Establishing the norms of scientific argumentation in classrooms", Driver, Newton and Osborne (2000) present two primary reasons for teaching argumentation in science education. First of all, students need to develop an accurate image of science; that is, students need to be presented with the socially constructed nature of scientific knowledge (Kolsto & Ratcliffe, 2008). To this end, students need to be given the opportunity to engage in argumentation, to formulate explanations and to evaluate evidence (Duschl & Osborne, 2002). Given that science is socially constructed, science teaching should focus on discursive practice and encourage argumentation. The second reason put forward as to why teaching of argumentation is important in science education is based on the notion that science involves controversial socio-scientific issues, and thus, students need to be develop competence in constructing and analysing arguments involving controversies (Kolsto & Ratcliffe, 2008). In this way, students will be equipped with the ability to think scientifically through everyday issues and understand scientific practice (Newton, Driver, & Osborne, 1999).

Furthermore, according to Osborne, Erduran and Simon (2004), incorporating argumentation as a central element into science classes has two main functions: The first is the heuristic function, which refers to engaging learners in the coordination of conceptual and epistemic goals. The second function is to make student scientific thinking and reasoning observable so that formative assessment can be carried out by teachers or instructors (Osborne, Erduran, & Simon, 2004). Consequently, integrating argumentation within the curriculum of science education not only engages learners with conceptual and epistemic goals but also enables teachers to carry out formative assessment (Duschl & Osborne, 2002).

The presence of argumentation practices in science classrooms makes several contributions to the learning. For example, in the discourse of argument, students are provided with opportunities to present and defend their ideas. Like scientists, during argumentation, students need to explain their ideas with support for judgment and be open to alternative ideas by evaluating the evidence. Examples of such practices are reported in studies by Kim and Song (2006) and Sampson, Grooms and Walker (2009). Kim and Song (2006) reported that during argumentation, middle school students, who were performing open-ended inquiry tasks, showed improvement in their interpretation and methods of experiments. Sampson, Grooms and Walker (2009) found that argument driven inquiry enabled students gain scientific literacy and allowed them "to develop scientific habits of mind, provide evidence for explanations, and think critically about suggested alternatives" (p.47).

The argumentation studies addressing the understanding of scientific epistemology resulted in the observation that students have to be in instructional contexts where they have to make explicit epistemic decisions in order to understand scientific practices in a way scientists do (Sandoval & Millwood, 2008). Sandoval and Millwood argued that to make the epistemic decisions explicit, there should be strategies such as constructing and evaluating arguments. Similarly, Jimenez-Aleixandre and Erduran (2008) claimed that argumentation, involving the justification of claims through evidence, may support the development of scientific epistemology and understanding of the practices of the scientific community.

Considering the role of argumentation in developing conceptual understanding, research indicated that rather than the quantity of arguments, the type of argumentation used and the quality of the information in the claims are important in relation to learning gains. For example, Cross, Taasoobshirazi, Hendricks, and Hickey (2007) reported a study with 28 high school biology students and investigated the relationship between learning gains, and engagement in scientific argumentation. The authors provided evidence of the argumentative structures, the quality of these structures, and the identities that students take on during collaborative group work were influential on student learning and achievement in science.

Argumentation does not only resulted in increasing motivation and collaboration in learning, but also effectively incorporate metacognition, which is claimed to be important for conceptual change learning by Georghiades (2000). Hall and Sampson (2009) indicated that reflection, which occurs during argumentation, is a useful tool to support metacognition since students have a chance to articulate, justify, and reflect on the discussed concepts. Mason and Santi (1994), who worked with 5th-grade students while studying pollution, identified levels of metacognitive awareness during argumentation, such as awareness of what one knows, awareness of why one knows something, awareness of knowledge construction procedures, and awareness of changes in one's own conceptual structures. Duschl, Ellenbogen, and Erduran (1999), who worked with middle school science students, also stressed the connection between argumentation and metacognition and they suggested that argumentation could be used to raise metacognitive awareness.

Similar contributions of argumentation in science classrooms are also reported in national studies. For example, Eşkin (2008), who investigated the effects of argumentation on the tenth-grade students' reasoning and argumentation levels, indicated that there was an interaction between the students' reasoning levels and argumentation levels. The researcher argued that the application of argumentation within the classes have positive effects on the students' argumentation levels and partly on their reasoning levels. Yeşiloğlu (2007), who made a comprehensive study about the effectiveness of argumentation on 10th grade students’ understanding of concepts about gases, and the effectiveness of argumentation materials on students’ understanding of nature of science, reported that students which were instructed through argumentation had higher achievement and conceptual change scores. Uluçınar-Sağır (2008) investigated the argumentation based science education on the success of the student, their attitude towards science, their perception of the concepts related to nature of science and their willingness to participate the argument. The researcher indicated that argumentation approach resulted in higher success rates and significant differences in the perception of the concepts related to nature of science.

The research examining the role of argumentation in increasing investigational capability had either problem solving activities, laboratory activities or inquiry activities. For example, a study which explored the problem-solving process by focusing on students' arguments (Kelly, Druker, & Chen, 1998), a scientific task, the 'Electric Mysteries' performance assessment, which required students to apply their knowledge of electricity to solve a problem, was used. The results showed great variability in the students' argument patterns. However, the researchers stated that a large number of warranted arguments did not mean that students engaged more in argumentation or they possessed greater subject-matter knowledge. The researchers explained this condition that students should feel compelled to provide an explicit warrant, and it is not possible in procedural tasks (Kelly, Druker, & Chen, 1998).

According to McDonald and Kelly (2012), the rationale underlying these functions is based on three central premises. First of all, argumentation provides students with opportunities to engage in relatively authentic scientific practices. The focus on engaging students in discourse practices stems from studies revealing the importance of students engaging in “talking science” and learning discourse through participation. Secondly, argumentation may enable students to learn the knowledge of a certain discipline in more thoroughly and deeply. Argumentation is viewed as a pattern of science discourse that can equip students with a deeper understanding of science. Third, argumentation is generally regarded as a means to teach about the nature of science. Enabling students to engage students in generating evidence-based claims may make teaching and learning nature of science more effective (McDonald & Kelly, 2012). Thus, it can be said that argumentation plays a crucial role not only in the development of a better understanding of the epistemic basis of science but also in the achievement of a better conceptual understanding of science as well (Osborne, 2005).

Argumentation in science education is not just a linguistic activity. It necessitates the selection of relevant knowledge, appropriate documentation and information sources, and analysis utilizing certain skills (Erduran & Jiménez-Aleixandre, 2012). That is, it requires the coordination of theory, evidence, and methodology common in argumentation in scientific reasoning (Garcia-Mila & Andersen, 2008).

In conclusion, as Osborne, Erduran and Simon (2004) indicates and the abovementioned literature supports that within a social context where scientific issues increasingly influence cultural elements, where social practices undergo changes in light of scientific evidence, and where the public hold feelings of ambivalence and anxiety regarding science, there is an urgent need to improve the quality of students' understanding of the nature of argument in general, and argument in a scientific context in particular. Therefore, science education should assume the responsibility of developing students' ability to understand and practice argumentation through scientifically valid ways, and enable them to recognise the strengths as well as the limitations of arguments in scientific contexts (Erduran, Osborne, & Simon, 2005).

Research on scientific and socio-scientific argumentation

Based on the contention that argumentation has a central and distinctive role in the practice of science, there seems to be agreement in theory and practice that argumentation should be a central and integral part of science education. Argumentation in science classes emerge primarily in two contexts, namely the context of scientific issues and that of social issues. In the former context, students engage in argumentation in relation to scientific issues strictly, without any consideration of their social implications. Interpretation of their experiment results may illustrate this use of argumentation. On the other hand, in the latter context, students are concerned with the social aspect of science, in which argumentation takes place to debate controversial issues for personal or political decision-making (Kolsto & Ratcliffe, 2008).

There are numerous benefits of argumentation in the context of scientific issues. First of all, arriving at an understanding of the norms involved in scientific argumentation may enable students to comprehend the epistemological foundation of scientific practice (Sandoval & Millwood, 2008); in other words, students can develop an understanding of the fact that scientific arguments are means of justifying beliefs and the underlying rationality within the context of science (Osborne, Erduran, & Simon, 2004). Another benefit is that students gain practice in analysing and evaluating data and then decide whether or not to make use of it as evidence for a claim. In this sense, they learn the structure of scientific arguments, consisting of a claim supported with evidence and a rationale. They learn that the evidence is actually the data, which come in different forms, ranging from traditional measurements (e.g. pH, mass, temperature) to observations (e.g. colour, descriptions), and from knowledge to research findings (Kolsto & Ratcliffe, 2008; Walker & Sampson, 2013). The condition is that the data should be analysed and interpreted to be considered as evidence as well as its validity or the relevance should be evaluated in support of a claim (Walker & Sampson, 2013).

In terms of the argumentation enforcing decision-making skills, one study was conducted with a maths classroom in Greece within the scope of a Greek-Danish Project in Mathematics Education (Patronis, Potari, & Spiliotopoulou, 1999). The aim of the study was to explore the ways in which students make decisions when they deal with real-life problems. Investigating the quality of the arguments was also a part of the purpose of the study. The task students undertook in the study required students to provide justification for their proposals regarding a social task and necessitated the use of scientific knowledge, but it did not impose the use of any specific kind of scientific knowledge. The implementation of the task proceeded as follows: first, the teacher asked each student to write their opinions regarding the enlargement of another road leading to their school. Two weeks later, based on the responses received, the teacher presented ‘the main problem’.

In the next stage, the students presented their justified proposals, during which they made use of different kinds of argumentation, to the whole class. Two weeks later, students were asked to choose the best proposal among the ones presented. To do so, they held a discussion and then voted for the best proposal, which was to be sent to the City Council for further initiatives. After a few months, the project was taken up again in a new form. This time the theme was based on the proposal of the student for the enlargement of the road that had come second in the voting. The proposal entailed the construction of a bridge and project focused on the design of this bridge. Results revealed that the nature of the arguments varied with the tasks assigned. Two dimensions were identified, namely the process of argumentation and the different kinds of pragmatic arguments. With respect to the first dimension, that is the process of argumentation, it was observed that students argued mainly in favour of their own proposal rather than attacking other proposals. However, they did have to attack other students’ proposals in cases where they had to answer questions regarding their own proposal. As regards the second dimension – the different kinds of pragmatic arguments, namely qualitative, semi-quantitative and quantitative – it was found that students engaged in qualitative arguments in the initial part of the project. That is, students' opinions were based on personal values or values of the society. Students also resorted to semi-quantitative arguments, which meant that they made use of variable quantities whether in isolation or in relations. This kind of thinking enabled students to focus on the situations without paying attention to the complexities inherent in exact relationships. In the last part of the project based on the design of the bridge, students more often used quantitative arguments during which they made use of numbers, estimated calculations, formulas etc. to discuss such issues as speed in terms of force, the slope, length and height of the bridge. In conclusion, the study showed that students could develop arguments and reach decisions when they were confronted with a situation in which they were really involved (Patronis, Potari, & Spiliotopoulou, 1999).

With respect to the inclusion of argumentation about socio-scientific issues, science educators argue that socio-scientific issues play a crucial role in the development of a responsible citizenry capable of applying scientific knowledge and habits of mind (Driver, Newton, & Osborne, 2000; Kolsto, 2001; Sadler, 2004). Socio-scientific issues (SSI) are regarded as multifaceted, open-ended, and contentious dilemmas with no clear-cut answers (Sadler, 2004). These issues are generally resolved through informal reasoning and provide an opportunity for the development of argumentation skills, NOS conceptualizations, evaluation of information, and the conceptual understanding of science content (Sadler, 2004). Integration of socio-scientific issues into science classrooms aims to equip students with the skills necessary to deal with science-based issues that shape their current and future world (Driver, Newton, & Osborne, 2000; Kolsto, 2001; Sadler, 2004). That is, authentic problems and ideal topics for argumentation are presented, enabling the contextualized use of argumentation based pedagogies that provide students with the opportunity to explore moral issues, which are believed to be the essence of SSI (Zeidler & Sadler, 2008) as these skills are believed to help foster students' intellectual and social skills.

It is challenging for students since on the one hand, the topics are controversial, thus open to multiple views and argumentation, and on the other hand, SSI requires an interdisciplinary approach, requiring students to synthesize information from different domains (Simonneaux, 2008). In addition, SSI requires not only content but also social dimensions and values, which have an impact on students' argumentation.

A case study conducted in a public high school in Vigo, a small city in Spain, illustrated the impact of social dimensions and values on students' argumentation. The study aimed to investigate the components of knowledge and skills needed to carry out argumentation and to reach a decision in socio-scientific contexts and to identify them in classroom discourse in the context of wetland environmental management (Jiménez-Aleixandre

& Pereiro-Munoz, 2002). The participants of the study were comprised of 38 students in 11th grade at a high school. These students were assigned to produce a report about the extent of suitability of a pipe proposal and to produce alternative proposals. The analysis procedures of the study were based on examining the argumentation and decision making steps students engaged in and then comparing them to those of an external expert in terms of three aspects: (i) the use of relevant conceptual knowledge, (ii) the ability to exercise critical thought in processing different sources of information and authority, and (iii) the ability to develop criteria for evaluation. Hence, data were collected through audio and video recordings of the sessions and small group discussions, field notes from an external observer and students' individual and collective reports and other work collected in their portfolios. Additionally, one year later interviews with some of the students and with the outside experts were conducted again. The recordings of students' conversations were transcribed and analysed by means of the argument schemes of Toulmin (1958) and Walton (1996). Findings revealed that students had combined ecological concepts (e.g. impact, wetland or water) with technical information. Moreover, to reach a conclusion they also applied conceptual knowledge at a deeper level (e.g. the impact of the drainpipe on the animals and plants by means of lack of water or the destruction of their habitat). When their claims were compared to those of the external expert, a significant amount of parallelism was observed, which supports the argument that students are not solely passive knowledge 'consumers'. What's more, value judgements also played a role in students' decisions as they had placed higher considerations to ecological issues than to economic ones (Jiménez-Aleixandre & Pereiro-Munoz, 2002).

Kolsto (2006) aimed to gain insights into how students employed knowledge and values in arguments they utilized support their decisions regarding controversial socio-scientific issues. Interviews were held with 22 students from four science classes in Norway on the local construction of new power lines and the possible increased risk of childhood leukaemia. The study looked into the types of arguments students employed while trying to make a decision and the interplay between knowledge and personal values. Findings revealed that five different types of arguments were employed by the students, namely the relative risk argument, the precautionary argument, the uncertainty argument, the small risk argument, and the pros and cons argument. In addition, it was seen that students resorted to both scientific and non-scientific knowledge, while producing arguments based on the information that was available or postponing the decision until more information was available (as in the uncertainty argument). It was also observed that students had not looked up the additional information that was needed to arrive at a decision during the time period between the preparation stage and the interview.

As an implication of this finding, the researcher suggested that students in science classes should have easy access to a range of information and viewpoints accompanying the frameworks for argumentation and decision-making, and the critical examination of information. Another finding of this study was that students' decisions were solely based on research-related information; hence, some students' decisions were based on very restricted range of knowledge domains. When the different types of arguments employed by students were compared, it was observed that those who utilized the precautionary argument had highlighted ethical values, which enabled them to make a straightforward decision. On the other hand, those using the uncertainty argument and the pros and cons argument evaluated and compared scenarios and arguments, arriving at conclusions in a higher number of problems. In conclusion, it is advised by the researcher that students finding it difficult to prioritize and decide which argument they should use to guide their decision should become more aware of their personal values and gain more experience in selecting among conflicting values (Kolsto, 2006).

A study, carried out with Turkish pre-science teachers (PST), aimed to examine their informal reasoning in terms of SSI and the factors impacting their informal reasoning (Topçu, Yılmaz-Tüzün, & Sadler, 2011). Interviews were held with 39 participants. Seven SSI scenarios, which were taken from previous studies of SSI and informal reasoning, were used in the interviews. Data collection was made through the Informal Reasoning Interview (IRI) and Moral Decision-Making Interview (MDMI) protocols, which are specifically designed for the exploration of informal reasoning and the factors manipulating informal reasoning. Findings demonstrated that the informal reasoning presented by the participants to both the genetic engineering and global warming issues included both cognitive and affective domains. That is, participants resorted to their 'reason' to comprehend the issue and then arrived at a decision based on motions in most of the scenarios. However, there were those who relied solely on reason to defend their claims or solely on emotive reasoning, using emotions such as empathy and sympathy to resolve problems. In some other cases, participants provided instant responses, which is a pattern of thinking termed intuitive informal reasoning. However, it was found that despite the variety, rationalistic informal reasoning was more frequently employed. When analysed closely, it was found that the context or nature of the different SSI had an impact on what type of informal reasoning was employed. Furthermore, the study found that personal experience also played a critical role in the decision making process regarding SSI as participants who had familiarity with certain topics and unfamiliarity with others provided responses with varying patterns of informal reasoning (Topçu, Yılmaz-Tüzün, & Sadler, 2011).

Studies in related literature reveal that people are not equipped with the skills to evaluate information regarding socio-scientific issues. More specifically, studies report that people generally accept information at face value, utilize evaluative criteria that are inconsistent, and focus on apparent components of the information and/or source; suggesting that there is a need for explicit instruction on strategies that students can use to evaluate scientific reports and experiences in distinguishing between scientific evidence and other types of information (Sadler, 2004).

Thus, science teachers have an important role to play. They need to be aware that reaching decisions on SSI issues necessitates students to master scientific models, concepts and skills, together with knowledge about science (Erduran & Jiménez-Aleixandre, 2012) since many of the studies in related literature support the fact that conceptual understanding of the context or material that underlies socio-scientific issues is crucial and a prerequisite for informal reasoning of the issues in subject (Sadler, 2004). Hence, teachers need to be aware of their students' understanding of the nature of science and be able to provide explicit instruction in order to help their students develop their understanding of the nature of scientific claims (Kolsto & Ratcliffe, 2008; Simonneaux, 2008).

Zohar and Nemet (2002) explored the learning outcomes resulting from explicit teaching of reasoning patterns incorporated into the teaching of scientific content. More specifically, this study examined the impact of teaching argumentation skills explicitly within the context of controversies involved in human genetics upon both biological knowledge and argumentation skills. The participants were divided into two groups: experimental (N=99) and comparison (N=87). All the participants in the study learned basic concepts in genetics before the study began and additional, advanced concepts in genetics during the study. However, while those in the comparison group learned them through the traditional method; i.e. they were provided with a special booklet that presented the genetic information in a traditional textbook approach. On the other hand, those in the experimental group learned the concepts in a non-traditional way within a unit called "Genetic Revolution" with explicit instruction on argumentation skills. In the experimental group, the data collected were based on students' worksheets, transcripts of audiotaped discussions, and students' responses to the written pre- and post-tests. The data were analysed to examine students' ability to construct arguments, alternative arguments, and refutations and whether they could justify them. The criterion employed for analysis was whether students included in their responses at least one conclusion and justify it.

After the intervention that had been conducted, it was found that integration of explicit teaching of argumentation into the teaching of dilemmas in human genetics had boosted students' performance in both biological knowledge and argumentation skills. There was a significant increase in the frequency of students who made use of correct, relevant biological knowledge while formulating arguments. Students in the experimental group scored significantly higher in a test on genetics knowledge than those in the comparison group. An increase was also observed in the quality of students' argumentation. Hence, the results obtained from the experimental group indicate that explicit instruction had a positive impact on improving students' scores in the argumentation tests with large effect sizes. In addition, findings indicated that students' scores improved not only in the genetic argumentation tests but also in the transfer tests, which showed that students had the ability to transfer their reasoning abilities taught in the context of dilemmas in genetics to dilemmas emerging in everyday life. An increase in the number of justifications and the complexity and quality of the arguments produced by the students was also observed (Zohar & Nemet, 2002).

Another similar experimental study was carried out recently by Khishfe (2014), which aimed to (a) explore the impact of explicit nature of science (NOS) and explicit argumentation instruction in the context of a socio-scientific issue on the argumentation skills and students' understandings of NOS, and (b) examine the skills of students in terms of transferring NOS understandings and argumentation skills learned in one socio-scientific context into other similar, familiar and unfamiliar contexts. A total of 121 seventh grade students from two schools in the city of Chicago in the USA participated in the study. There were two intact experimental groups, which underwent an intervention involving an eight-week unit about the water usage and safety. The experimental groups were taught by two teachers, both of whom had received a methods course with the researcher to learn about NOS and argumentation as part of the course. Explicit NOS instruction, which lay emphasis on empirical, tentative and subjective NOS aspects, was integrated into the teaching of all groups. However, only Treatment I groups additionally received explicit instruction on argumentation. Each participant was administered a questionnaire and the data obtained from these questionnaires were analysed and categorized into three as naïve, intermediary, or informed arguments. Moreover, the progress in participants' responses for each of the three components of argumentation (argument, counterargument, and rebuttals) was evaluated. Participants were also interviewed and administered pre- and post-test employing open-ended items on two socio-scientific issues in order to assess their learning and transfer of argumentation skills and NOS understandings. According to the findings, there were significant improvements in the learning of argumentation practice and NOS understandings of the participants in Treatment I group. Further, the participants in this group had made connections to argumentation when displaying their NOS understandings by the end of the study. On the other hand, even though improvements were also observed in the learning and transfer of NOS understandings of the participants in Treatment II group, there was only some improvement regarding argumentation practice (Khishfe, 2014).

In another study, the SEE-SEP (Sociology/culture, Economy, Environment/ecology, Science, Ethics/morality, and Policy) model, which is an analytical model used to frame the preliminary coding of data and examine the multiple perspectives inherent in the informal argumentation of different SSI topics in student responses, was employed in a study conducted in Sweden by Christenson, Rundgren, and Zeidler (2014). Three upper secondary schools in Sweden participated in the study. A total of 208, 18-19-year-old, upper secondary students (124 females and 84 males) voluntarily participated in the study. Among these students, 103 were from the science program and the rest of the students (N=105) were from the social science program. In the study, the four SSI that were selected were global warming, genetically modified organism (GMO), nuclear power, and consumer consumption. Among the 208 students, it was found that global warming was the SSI most chosen, followed by the issue of consumer consumption. By means of the SEE-SEP model, the six subject areas dealt with in SSI: sociology/culture, economy, environment/ecology, science, ethics/morality, and policy. Findings indicated that there was a variation among the four different SSI topics. The participants displayed a tendency to produce more justifications in the topic of consumer consumption than in the other three SSI. Even though most students had chosen to argue about the topic of global warming, the average number of justifications produced for this topic was the lowest. Another finding that the study yielded was that social science majors had used more justifications than science majors in each of the four SSI topic areas. Both social science and science majors had presented most justifications from the subject area of science on the GMO and nuclear power issues, from the subject area of environment/ecology when arguing about global warming, and from the sociology/culture subject area when arguing about consumer consumption. Consequently, the results of participants' choices of SSI showed that familiarity to the topic plays a crucial role. As for the number of justifications produced, the participants' background in the discipline was influential. Overall, the social science majors were found to have used more justifications than the science majors among all four SSI, the reason of which may be attributed to the fact that the students attending the social science program had a higher level of familiarity with the construction and development of arguments. This study shows that, in science education, the multi-disciplinary nature of SSI necessitates the engagement of teachers from different disciplines when teaching argumentation on SSI in order to provide students from both social science and science programs with the best possible conditions in which to develop argumentation skills (Christenson, Rundgren, & Zeidler, 2014).

Another recent study by Cetin, Dogan and Kutluca (2014) aimed to (i) define pre-service science teachers' (PST) content knowledge related to cloning, (ii) examine the quality of their socio-scientific argumentation in regard to certain ill-structured cloning scenarios, (iii) identify whether there is a relation between PSTs' content knowledge and the quality of socio-scientific argumentation, and (iv) reveal reasons underlying changes in the quality of individuals' socio-scientific argumentation in relation to the level of their content knowledge. The participants of the study consisted of 54 pre-science teachers, who were divided into three groups - high, middle and low achievers - according to the scores they had received in a conceptual understanding test that was administered on the topic of genetic cloning. Small discussion groups were held, and data were collected by means of three different data collection tools: the Cloning Conceptual Understanding Test (CCUE), three socio-scientific scenarios (based on the issue of cloning), and semi-structured interviews. The implementation of the project lasted over 7 weeks. The arguments generated by PSTs were evaluated in terms of their conformity with the Toulmin argument pattern. Findings indicated that generally low achiever PSTs, compared to the other two groups, were able to generate stronger rebuttals. However, the difference was not reported to be at a significant level. Thus, this finding showed that an individual's domain-specific level of content knowledge may not be a determining or indicative factor in the production of higher- or lower-quality socio-scientific argumentation. Another finding based on the qualitative analysis was that the average scores indicating the quality of socio-scientific argumentation among the lower and upper groups were similar, but lower among the middle group. However, there was no significant difference between the quality of the socio-scientific argumentation of the lower, middle, and upper groups. Consequently, the researchers concluded that there was no significant connection between prospective teachers' conceptual knowledge and the quality of their socio-scientific argumentation. All interviewees were of the opinion that content knowledge was an important factor in the quality of argumentation. The lower and middle groups complained that they could not produce arguments of high quality owing to their lack of content knowledge, while the upper group stated that they rather than making use of content knowledge, they had resorted to their feelings and opinions. One other factor influential in the argumentation process was reported by the middle group, who said that the argumentation process was often interrupted when there was a lack of interest in the subject. Based on the results of the study, the researchers concluded that learners should be provided with settings in which they can produce socio-scientific arguments from early on in order to be equipped with the necessary argumentation skills (Cetin, Dogan, & Kutluca, 2014).

The fact that SSI should be introduced in science classrooms is also supported with SSI research findings, which argued that most learners do not demonstrate high-quality argumentation, lacking the ability to express and justify their positions, are reported to be making claims without providing adequate justifications, and not giving place to counter arguments and refutations (Sadler, 2004). However, integrating SSI into science classrooms is not an easy task. The challenge derives from the complexity of the issues and this imposes high demands on teachers (Erduran & Jiménez-Aleixandre, 2012).

Zeidler and Sadler (2008) emphasized that one area which needs consideration if SSI is to be integrated into classroom science activities is the frameworks used to support and evaluate argumentation practices. They indicated that standard argumentation frameworks may be sufficient in scientific contexts, but they may not function well to explain the moral aspect of argumentation in socio scientific contexts because the moral duties, obligations, commitments and the like must be considered in SSI, in addition to the technological decisions made upon scientific information. If morality is not included in discussions, the functional understanding of science literature may not be fully realized (Zeidler & Sadler, 2008).

Hence, educational programs and research that aim to promote argumentation and character development should pay specific attention to fostering students' ability to express coherent and reliable arguments, diagnose possible threats to positions and counter-positions, and establish refutations (Zeidler & Sadler, 2008). To this end, teachers can "(a) highlight the significance of argumentation in scientific and socio-scientific contexts, (b) provide students with the opportunities to engage in these argumentation practices, (c) emphasize the connections between science and morality especially with respect to SSI, and (d) scaffold students efforts to reflect critically on their own arguments and argument patterns as well as those of their peers" (Zeidler & Sadler, 2008, p. 213). In brief, teachers need to encourage critical reflection not so that students may change their arguments, but so as to equip them with the skills to produce high-quality arguments.

Research, as also reviewed by Sadler (2004), shows that one way to reach this end is to encourage personal networks between students and the issues discussed. Another way is to explicitly address the value inherent in justifying claims, and one other is to highlight the importance of paying attention to contradictory opinions. Students should be provided with opportunities to engage in sophisticated argumentation, to practice justifying claims and attending to counter positions, and analysing argumentation to increase their awareness regarding what constitutes well-reasoned arguments. Consequently, it is evident that curricula which aims to increase students' understandings of what constitutes evidence and data in science need to be developed. In addition, these curricula need to incorporate the teaching of strategies for critically evaluating the content and sources of knowledge presented as scientific and made available to the public (Sadler, 2004).

Research on oral and written argumentation

Studies in literature related to student argumentation have dwelled on participants of different age groups and on two basic contexts: oral and written argumentation (Sandoval & Millwood, 2008). That is, while some researchers focus on student engagement in collaborative dialogic argumentation (Sampson & Clark, 2011), some others dwell on the quality of students' written arguments (Sampson & Clark, 2009; Walker & Sampson, 2013).

Oral argumentation are widely studied within contexts of collaborative inquiry or problem-solving by examining the dialogue that students engage in during collaborative argumentation, and the epistemic moves that students make during such conversations (Sandoval & Millwood, 2008). Studies focusing on oral argumentation have yielded results indicating that students generally make claims without justifying them clearly (Erduran, Simon, & Osborne, 2004; Jiménez-Aleixandre, Rodriguez, & Duschl, 2000; Kelly, Druker, & Chen, 1998). It is also observed through these studies that (1) students sometimes justify their claims only when they are challenged; (2) claims are often made without relating them to other elements (Jiménez-Aleixandre, Rodriguez, & Duschl, 2000); and (3) the justifications of students that are provided for claims appear in a number of forms, ranging between appeals to empirical evidence as well as to hypothetical or theoretical ideas (Kelly, Druker, & Chen, 1998; Sandoval & Millwood, 2008).

In addition to studies on argumentation that examine oral argumentation, there are also studies on argumentation conducted through examinations of student writing. Analyses performed in argumentation studies examining student writings tend to focus, just as in oral argumentation studies, on the structure and quality of arguments produced by students. Similar to studies of oral argumentation (Erduran, Simon, & Osborne, 2004; Jiménez-Aleixandre, Rodriguez, & Duschl, 2000), studies in written argumentation have been based on the implementation of Toulmin's (1958) argument structure (Bell & Linn, 2000). Most of the findings obtained from these studies indicate that even though writing arguments seems to contribute to students' understanding of important scientific ideas, students' ability to produce scientific arguments through writing is insufficient (Bell & Linn, 2000; Sandoval & Millwood, 2005). As regards the provision of justifications, the situation seems to be no different than that in oral argumentation. That is, students generally do not provide sufficient justifications for their written claims (Sandoval & Millwood, 2005), or they often fail to establish clear associations between data and claims about data (Sandoval & Millwood, 2008).

Written argument in science education provides unique research opportunities and challenges as writing brings arguments to closure and enables the evaluation of the rhetorical aspects over time (Kelly, Regev, & Prothero, 2008). As writing is an essential strategy to engage students in the social and cognitive practices of forming evidence (Kelly & Bazerman, 2003), it also poses pedagogical challenges. First of all, if students' written argumentation skills are to be developed, then their language skills also need to be developed (Kelly & Bazerman, 2003). Secondly, written argument in science necessitates persuasive skills, the teaching of which also entails challenges (Kelly, Regev, & Prothero, 2008).

One specific study examining the formulation of written argument aimed to explore the ways students engaged in scientific reasoning practices by means of written argumentation (Kelly & Bazerman, 2003). In this study, university students' written scientific texts were subject to textual analysis in order to illustrate how general theoretical claims were linked to specific data while constructing evidence. Two samples were chosen among the students attending a writing-intensive university oceanography course, in which they were assigned to write a technical paper making use of multiple interactive geological data sets regarding plate tectonics. The written assignments of these two students were analysed in three ways: genre analysis was employed to identify the rhetorical moves utilized by the students to complete the academic task; a model of epistemic generality was used to reveal the relationships of theoretical assertions and empirical data; and an analysis of *lexical cohesion* was employed to map the recurrence and relationships of topics throughout the papers. As a result of the first analysis, it was found that each of the two students had used a set of rhetorical moves to carry out the writing task. The second analysis yielded results indicating that successful written arguments were those in which the epistemic level of the claims made had been adjusted to reach different rhetorical goals, to build theoretical arguments on specific data and method, to introduce key concepts for conceptual development, and to link multiple sets of empirical data to central constructs. The findings of the third analysis showed that the students had made use of key conceptual terms and established cohesive links across the majority of the sentences. The subsections tended to have denser cohesive links with other sections of the paper and tended to link semantic items of multiple epistemic levels (Kelly & Bazerman, 2003).

As regards the integration of written argumentation into science education, there is an approach called Science Writing Heuristic (SWH) which is employed in science classrooms. This approach necessitates the active encouraging of students to negotiate meaning both privately and publically in a learning environment that is rich in opportunities for argumentation and learning. The SWH approach also necessitates creating a pattern of reasoning that is embedded in a structure of argumentation, and incorporating language, reasoning, argumentation, and critical thinking (Hand, Norton-Meier, Staker, & Bintz, 2009). The SWH approach consists of both a student and teacher framework in which the nature of science is reflected as inquiry and argument, students are provided guidance by means of activities. More specifically, the SWH approach serves as a metacognitive support to encourage student reasoning about certain data. The SWH template for student thinking encourages learners to generate questions, claims, and evidence in order to make an argument based on valid reasoning. The SWH helps students to develop a deeper understanding of science contents through the phases of the student template or plan. This plan involves constructing and testing questions, justifying their claims with evidence, comparing their ideas with those of others, and considering how their ideas have changed through this process. The final stage of the SWH involves a student writing task. This task follows a continuous cycle of negotiating and clarifying meanings and explanations with their peers and teacher. The SWH approach has the potential to build learners' understanding of the nature of science, to strengthen their conceptual understanding, and to engage them in the authentic argumentation process of science. In brief, the SWH approach emphasizes the collaborative and constructive nature of scientific argumentation (Akkus, Gunel, & Hand, 2007).

This approach, the original name of which is 'Science Writing Heuristic', has been adapted to the Turkish language to be called 'Argümantasyon Tabanlı Bilim Öğrenme (ATBÖ) - argument-based inquiry approach'. In the ATBÖ (SWH) approach, which necessitates the effective use of reading, writing and speaking language skills, students construct knowledge by asking questions, making claims and supporting these claims with evidence in a learning environment based on research and inquiry (Günel, Kıngır, & Geban, 2012). This approach increases students' active participation in the learning process and, thus, can form a more effective learning environment.

A study on the impact of the inquiry-based SWH approach was conducted by Akkuş, Günel and Hand (2007). The main purpose of the study was to investigate the effect of the SWH approach as a treatment compared with traditional teaching approaches. It also aimed to find out whether its use impacted students' achievement on the post-test based on the quality of teacher implementation. Two groups of participants were involved in this study. The first participant group was consisted of seven teachers, each of whom was teaching different subjects (chemistry, physics, and biology) in different grade levels (Grades 7–11). Each teacher was asked to divide his/her classes into either control (traditional teaching approach) or treatment (SWH approach) for the study. In the end, there were a total of 11 control classes and 12 treatment classes. The second group of participants consisted of 592 students, 270 of whom comprised the control groups and 322 the treatment groups. All the teachers were required to attend a 2-day summer workshop based on the implementation of the SWH approach.

A mixed-method approach (qualitative and qualitative) was employed as the design of the study. The qualitative component of the research design consisted of an interpretive case method, the aim of which was to identify the quality of the teachers' implementation of the SWH approach. The quantitative component employed analysis of variance (ANOVA) and analysis of covariance (ANCOVA) models to explore possible differences across groups. Three criteria were established to identify the level or quality of the teachers' implementation of the SWH approach: dialogical interaction, focus of learning, and unit preparation and making connections. At the end of the study, the teachers' traditional teaching rankings were inversely related to the SWH rankings. The study yielded findings which showed that the quality of implementation is influential in terms of student performance, and that high-quality implementation of the SWH approach has significant advantages in eliminating the achievement gap within science classrooms. Results also indicated that it was the low-achieving science students who benefitted most from the implementation of the SWH approach. While the effect size difference between high achieving and low-achieving students in high traditional teaching was 1.23 standard deviation units, that for high SWH teaching was 0.13 standard deviation units. Findings also indicated that the maximum benefit for low-achieving students was gained when there was the implementation of SWH teaching was combined with language practices. That is, it is understood that students gain maximum benefit from the SWH approach when students are provided with opportunities to not only use inquiry-based activities, but also have debates and discussions before having to write their scientific arguments using the SWH format (Akkus, Gunel, & Hand, 2007).

Another study worthwhile citing is that carried out in a course on oceanography taught at a large research university in southern California (Kelly, Regev, & Prothero, 2008). The mentioned course integrated science, technology, and writing in order to develop students' scientific literacy. The course consisted of three hours of lecture and three hours of lab per week. Several content themes were treated, including ocean basins, plate tectonics, earth's atmosphere, oceans and world climate, waves and beaches, and world fisheries. For each topic, students were required to carry out group work to approach the scientific and socio-scientific issues from the perspective of a certain country. In the final activity, students were required to role-play an Earth Summit. As a member of the Earth Summit, students had to join a “Country Group” and role-play a science advisor, who was to present the point of view of their country. Thus, by exploring real earth data sets, students identified major science issues specific to their country. Students gathered relevant data, wrote scientific position papers, and discussed and presented their findings to their peers. The writing assignments were supported by weekly online assignments including homework, multiple choice quizzes,thought questions,mini-studies, and class presentations during lab, and small group discussions. In the first of the two papers, students were required to choose a country and develop a scientific argument characterizing the geological features in terms of plate tectonic activity. In the second writing task, students were allowed to choose an earth climate issue affecting the country of their focus.

The EarthEd software was employed, providing students with multiple tools for creating scientifically sound arguments regarding the point of view of their chosen country. These assignments were analysed from various aspects. First of all, the structure of the arguments was examined. Secondly, the epistemic criteria were assessed. To this end, the thesis statement of each paper was identified and lines of reasoning were examined. The third step in analysis was based on the initial quantitative results of the four papers chosen from among the 30 papers, for which there was high inter-rater reliability and variation in genre conventions. Findings revealed two patterns of argument across the two writing assignments as regards the strength of the arguments. First, stronger arguments emerged more in the plate tectonics paper than they did in the earth’s climate paper. Secondly, there was a clear difference between the two writing assignments in terms of the amount of evidence provided between poorly argued papers and well-argued papers. Arguments that were strongly justified with evidence tended to be explicit, convergent and focused in scope. In addition, students who produced these strongly justified arguments tended demonstrate an understanding of the unique rhetorical demands of the scientific paper. As for the argumentation strategies employed by the students, it was observed that multiple and converging lines of evidence based on valid inferences were employed. Furthermore, these lines of reasoning were well identified and annotated in the text, and they generally clearly illustrated the relevance of the data to their overall argument, using the data as justifications.

On the other hand, findings indicated that there were three categories of arguments that were not justified with evidence effectively. The first category of poorly evidenced arguments included those that did not clearly refer to supporting data. The second group included those arguments that had multiple data references and/or converging lines of evidence but no clear argument based on this evidence, so there was a mismatch between the evidence data and the argument. The third type was those arguments that referenced intangible evidence with minimal data. That is, the interpretations were based on evidence that was not presented to the reader. Findings also revealed that the writing samples that were very well-organized varied in the ways that data were linked to the central thesis of the student's argument in the assignment. When the four cases were closely examined, it was observed that there was variation in the ways that cohesion was developed across claims, the ways that claims across epistemic levels were coordinated, and how arguments from data were constructed. Thus, it can be concluded that these rhetorical features (coherence, coordination, and progressive construction) need to be taught to students in science classes in order to teach argumentation (Kelly, Regev, & Prothero, 2008).

Research on written arguments at the college level has mainly dwelled on non-majors and upper-level students. To illustrate, a study was conducted by Schen (2013) to explore and describe the argumentation skills of students who were biology majors (n=243) in a four-level undergraduate biology program at a public university. More specifically, the study set out to characterise the quality of TAP aspects in students' written scientific arguments and determine if quality improved as students progressed through the curriculum. A short, written argument instrument based on a hypothetical data set and scenario was utilized as a data collection tool. 243 students from biology classes voluntarily participated in the study. Normally, the traditional teaching method based on lectures was used in the courses with no focus on argumentation skills. An instrument was developed and administered to compare the ability of biology majors in constructing arguments across the curriculum. This instrument, which included a data table and a scenario, required students to identify the hypothetical evolutionary ancestor of a newly discovered bird. The data collected by means of the instruments were assessed using the corresponding rubric based on TAP. Major TAP aspects were identified using rhetorical patterns.

The assessment of the arguments focused mainly on the presence, articulation and coherence of biological content in each of the five TAP aspects, not on the accuracy of the content. Findings showed that, generally, students were able to arrive at an appropriate conclusion. There was a low positive correlation between the scores and course level. When the evidence provided by the students were assessed, it was found that the students were able to identify trends in the data, but often lacked specific evidence to support their claims. As for the students' line of reasoning, there was a significantly low positive relationship between course level and reasoning scores. Most important of all, the study yielded results indicating that students had poor skills in producing high quality arguments and that these skills did not show progress throughout the undergraduate biology curriculum. However, there was one exception to this generalisation. Despite being low, there was a positive relationship between reasoning score and course level. The scores reflecting the evidence aspect displayed patterns lacking specificity and relevance. Students across the course levels were generally able to detect the similarities in the data regarding the new and sample birds. However, they were unable to cite the key evidence. Nor were they able to produce counter arguments and refutations in their responses. When biology majors are given a scientific data set including two plausible claims, they are often expected to construct an argument justifying one claim over the other. However, the results obtained in this study showed that biology majors were more comfortable with supporting a single claim without other considerations (Schen, 2013).

Another study, which contributed to the literature on the use of argumentation and students' epistemological ideas in constructing arguments, was carried out by Aslan (2014) in a Turkish high school. The purpose of the study was to seek the answers to the following research questions: a) how is the quality of the arguments generated by 9th, 10th, 11th and 12th grade high school students in relation to claim, evidence, and justification? b) Do the grade level and content affect students' ability to construct acceptable arguments? c) How are students' evaluation skills of arguments? A total of 165 participants took part in the first stage of the study. Of these participants, 52 were ninth graders, 38 were tenth graders, 42 were eleventh graders, and 33 were twelfth graders from different high schools in Turkey. A total of 495 written arguments were collected from 165 students. The participants of the second stage of the study were composed of 8 pre-service science teachers (2 freshman students, 2 sophomore students, 3 junior students and 1 senior student). As for the procedures followed in the study, in the first stage, high school students were asked to construct written arguments about the topics of chemical reactions, nature of matter, melting and dissolution. Then these arguments were evaluated for the presence and quality of the components proposed in Toulmin's Argument Pattern, namely evidence, claim, and justification. After the collection and analyses of the data were completed, the second stage was initiated. In the second stage of the study, 14 of the written arguments that were produced by the high school students were chosen which were analysed by the pre-service science teachers. To this end, the semi-structured interview technique was employed so that the written argument evaluation skills of the pre-service science teachers could be evaluated.

Furthermore, an analysis framework was developed and used for the purpose of evaluating student arguments in terms of claim, evidence, and justification. The study yielded findings which revealed that 84.6% of the arguments constructed by the 9th graders on the topic of chemical reactions were found to be correct regarding the selection of the claim, 48.1% of them had an acceptable justification, and 7.7% of the justifications had completely supported the claim. When the arguments constructed by the 10th graders were examined, it was found that 94.7% of them had selected the claim correctly, and 71.1% of them had provided an acceptable justification. However, only 5.3% of the justifications provided completely supported the claim. Of the arguments constructed by the 11th graders, 78.5% were found to be correct as regards the selection of the claim, 50% of the arguments had an acceptable justification, and only 2.4% of the justifications proposed by the arguments completely supported the claim. In all the arguments constructed by the 12th graders, the claim was correctly selected, and 97% of these arguments had provided an acceptable justification. However, only 9.1% of the justifications completely supported the claim. These findings suggested that the arguments established by the high school students in relation to chemical reactions were more successful than those constructed in relation to the nature of the matter and melting and dissolution. Thus, it can be concluded that argument construction is closely connected to the content of topic (Aslan, 2014).

In related literature there are not only studies examining oral argumentation or written argumentation, but also those that attempt to connect both oral and written discourse. Berland and McNeill (2010) indicate that oral argumentation is more complex than written arguments, and they suggest that the presence of an audience during the act of argumentation stimulates students to develop rich, convincing arguments in response to the questions and critiques of their peers. Berland and Reiser (2009) suggest that these two contexts (oral and written argumentation) may necessitate different instructional strategies to help students develop better skills. However, Walker and Sampson (2013) maintain that students can make significant progress in both oral argumentation and written argument if they participate in a series of investigations that place a great deal of emphasis on the generation and evaluation of both written and oral arguments. Based on their study, Walker and Sampson (2013) also claim that that there is a relationship between the quality of the argumentation that takes place within a group and the quality of the argument that the individual students write on their own.

In another study, the effect of training on argumentation and specifically the effect of the analysis of argumentation of influential people with conflicting views were investigated in a quasi-experimental study with a class of 24 students in 12th grade (Simonneaux, 2008). In the first stage of the study, the students were given two texts which included conflicting opinions. The task required the students to write their own opinion. The students were then ranked based on their number of valid arguments they had constructed and the number of supporting arguments they provided for a given point. During the second stage of the study, the experimental group, half of whom was composed of the “good debaters” (n=11) and the other half (n=13) of the “bad debaters”, participated in task in which they needed to analyse and compare two new texts with opposing views. Then followed the third stage, during which both the experimental (the remaining 10 students) and the control group (the remaining 11 students) expressed their opinions on two new texts containing conflicting views about the interaction between developing countries and the production of GMO (Genetically Modified Organisms). Subsequently, a debate was held. The results of the study demonstrated that approximately half of the students in the experimental group, who were trained between pre-test and post-test, had developed more sophisticated written arguments considering the number of valid arguments and number of supporting arguments for a given point. It was found that students who had already had a political implication were able to integrate more content knowledge than the others. Furthermore they could develop much more sophisticated argumentation during oral debate than in their written texts. In brief, it can be concluded that the training was effective in improving the quality of written argumentation but not in improving the quality of the oral argumentation (Simonneaux, 2008).

The technology-enhanced learning environment is another context in which especially written arguments are supported and investigated. Clark, Stegmann, Weinberger, Menekse, and Erkens (2008) stated that students can be challenged to identify the relevant problem information within complex problem cases and then create a suitable solution strategy by means of technology-enhanced materials. In addition, evidence for argumentation can be collected by means of the rich representations that technology environments can offer. Technology environments can also increase students’ access to rich data to support their arguments, which may include structured knowledge bases, unstructured knowledge bases, media-rich representations, visualizations, and other formats. Students can benefit not only from access to data but also from access to scaffolding in the evaluation of that data. Moreover, technology-enhanced environments can support students in constructing sound arguments by means of this analytical scaffolding, and can directly support students’ construction of arguments and individual contributions within larger dialogic contexts. Another benefit of technology-enhanced environments in terms of the teaching of argumentation is that embedding intelligent real-time analytical capabilities into environments could foster collaborative argumentation and the construction of arguments and contributions. For instance, by means of real-time analytical capabilities students may be able to elaborate deeply while constructing arguments individually. In addition, technology environment can increase students’ awareness of their positions, the opinions of others, and the quality of their argumentation. Within technology environments, group compositions could be organized based on analyses of students’ positions. Grouping can even be shifted to introduce missing perspectives or critiques. What's more, such environments could also model argumentation practices for the teachers themselves by helping them interpret the argumentation practices of their students within the environment. These environments may also provide a means for supporting teachers' pedagogical practices in addition to enhancing their understanding of these pedagogical processes and the nature of argumentation (Clark, et.al, 2008).

A study in which the impact of the use of technology environments was explored was conducted by Zembal-Saul et al. (2002). The specific goal of their study was to explore the nature and development of pre-service teachers' arguments (i.e., structure and use of evidence; consistency with scientifically accepted knowledge) and the software scaffolds that influenced the development of their arguments. The participants of the study were pre-service secondary science teachers enrolled in a ten-week advanced methods course, which was followed by a five-week practicum experience. The Galapagos Finches software and the supporting curriculum, Struggle for Survival were intentionally selected owing to the focus allocated to creating a context for scientific inquiry and supporting the construction of evidence-based arguments. While data are explored using the Galapagos Finches software, graphs are automatically generated. This spares learners' energy and time to focus on analysing the data rather than constructing graphs. Graphs and other data examined by learners are automatically stored in the Data Log, which enables students to annotate the results of each component of the data they have been dealing with and categorize the results based on a discipline-specific framework so that they can look for patterns in the data. By means of the Explanation Constructor component of the software, students are able to express questions and their corresponding arguments. On the other hand, the Organiser panel enables learners to structure key components of their arguments and express claims that are specifically linked to supporting evidence imported from the Data Log. The participants, or instrumental cases, included in this study consisted of two pairs of pre-service science teachers.

The primary sources of data consisted of the electronic artefacts generated in the Galapagos Finches software environment and the videotaped interactions of both pairs as they studied the data set, constructed and revised their arguments, engaged in peer review sessions, and presented their arguments to the class at the end of the unit. The analysis of the data resulted in four major patterns. First of all, the pre-service science teachers had consistently constructed claims that were based on evidence from the investigation by using the software as they could easily import evidence from the Data Log to the Explanation Constructor and link them to specific claims using the linking tool. The software offered distinct spaces for learners to generate evidence (via Data Query), to collect and interpret evidence (via Data Log), and to express their arguments (via Explanation Constructor). Thus, learners were able to distinguish between generating evidence and building arguments. Secondly, the results indicated that although pre-service science teachers consistently based their arguments on evidence, they still displayed various limitations reported in related literature. To illustrate, their arguments were not complex in that they did not include alternative causes (e.g., natural selection and/or change in behaviour) nor did they explore the possibility that different factors could be involved in the same cause (e.g., selection of different traits).

Furthermore, the pre-service science teachers' use of evidence was problematic. To be specific, only when they used their field notes did they use multiple pieces of evidence to support a given claim. They did not synthesize different types of evidence for any one claim (e.g., field notes and graphs). They seldom made use of the same piece of evidence more than once in their argument and they used graphs as evidence but they were not explained. They also displayed inadequate sampling of evidence; that is, they were unable to apply a domain-specific framework to identify and evaluate appropriate and effective evidence in the specific context. They neither questioned the evidence nor attempted to interpret it. Thus, it was viewed that neither the instructors nor the software could adequately support pre-service teachers in considering "what counts as evidence". One other point is that pre-service teachers had not supported their arguments with justifications. The third pattern of results indicated that the software functioned as a powerful tool in revealing pre-service science teachers' knowledge of evolution and natural selection. Finally, it was observed that the pre-science teachers' approach to the task had a strong impact on the way they had used the software. Consequently, the findings of the study suggest that if scaffolding strategies embedded in software are utilized appropriately, they can support learners in engaging in complex, long-term investigations. More specifically, software scaffolds can be influential in supporting the construction and development of scientific arguments based on evidence (Zembal-Saul, Munford, Crawford, Friedrichsen, & Land, 2002).

Another study related to argumentation in technology-enhanced environments analysed a customized online discourse system, which was designed to integrate and support scientific argumentation within the classroom (Clark & Sampson, 2005). The context was an online thermal equilibrium inquiry laboratory for eighth-grade students, who made use of a special interface to construct principles to describe the data they collected in the laboratory component of the project. These principles constituted the starting point for the online discussion. The software divided the students into discussion groups based on the different principles they constructed ensuring that each discussion group represented multiple perspectives. Then, the students critiqued one another's principles by following a set of guidelines. This allowed students to engage scientific argumentation discourse and inquiry. Thus, the study explored the efficacy of this personally-initiated discussion approach using TAP coding scheme. Personally-initiated discussions are believed to help students (i) synthesize data that they have collected, (ii) describe the data, (iii) engage in online discourse with which they can critique each other's arguments in light of the evidence and proceed toward consensus through scientific argumentation based on the evidence, and (iv) view models of productive scientific argumentation (Clark & Sampson, 2005).

The project was based on Web-based Integrated Science Environment Internet software, which included custom simulation modelling, electronic peer critique, and laboratory components. The focus of the second stage of the study was on the structural quality of the students' argumentation. In the second stage, the software used placed students in electronic discussion groups with students who had constructed different principles to explain the data. After collecting their data, students created principles to describe patterns in the data. As part of this process, the students were required to support their assertions and claims with evidence from their laboratories and other experiences. Eight online discussions involving a total of 84 students were randomly chosen from four classes of eighth-grade students who had completed the project during one semester under the supervision of an experienced teacher. Each online discussion involved approximately five pairs of students, who worked on the project in pairs over the course of six class periods (5 hours in total). The discussions were threaded and asynchronous. All comments were assigned a code. The eight discussions included 122 total episodes comprising 416 student comments. Of these episodes, 63 qualified as oppositional episodes and 59 did not. Most non-oppositional episodes tended to be very short. In most non-oppositional episodes, students did not include grounds for their support statements. Support statements without grounds comprised 37 of the 55 supporting comments in the non-oppositional episodes. The remaining two supported instances involving students to acknowledge changing their position in line with the initial claims. In summary, the non-oppositional episodes tended to be relatively unsophisticated in terms of scientific discourse structures. Students tended to accept what was written in the claim. The oppositional episodes included many more instances of clarification and queries than non-oppositional queries. In the personally-initiated discussions, 68% of the oppositional episodes in this study were at higher levels- including at least one rebuttal-, suggesting that personally-initiated discussions scaffold high structural levels of scientific argumentation. As for the rebuttals, many of them involved real-world examples or data from the project or prior laboratories. Statistically, analysis of variance yielded no significant difference among discussions or among class periods in terms of argumentation scores or number of comments (Clark & Sampson, 2005; Clark & Sampson, 2007).

Another study worth mentioning is that carried out by Akpınar, Ardaç, and Er-Amuce (2014), who aimed to develop and examine a system called Argümantaryum, a multimedia science learning environment where science learning through argumentation is facilitated. The specific goal underlying this study on Argümantaryum was to test whether students who used this multimedia science learning environment collaboratively with their peers under teacher guidance would be more successful in unit tests and develop better scientific discussion skills than (i) students using the same platform individually without teacher guidance, and (ii) those students who studied the same units with a teacher within a classroom based setting. A mixed method research design was employed integrating a quasi-experimental control group design with a pre and post-test. Both quantitative and qualitative data analyses procedures were implemented. The multimedia-rich online setting, Argümantaryum, offered interactive activities of on the curricular content of five learning units in the field of science for 6-8th graders. The system included seven different virtual activity rooms: observation/simulation room, video room, meeting room, decision room, game room, race room, and expert room. Each room was specifically designed to meet certain learning objectives for conceptual development or procedural skills. The system beings with the presentation of a contextualized problem, to which each student is required to respond or select a response as his/her claim. As the activities of the virtual rooms are carried out, the students collect data to serve as evidence for his/her claim, and construct or select arguments for the problem posed. The purpose of the activities in the system is to help students both learn the content of the curricular units, and develop skills necessary for scientific argumentation, namely prediction, observations, explanation, hypothesizing, testing claims and providing evidence. Activities on this multimedia learning environment range between operating and inspecting the given simulations as regards the problem case, conducting experiments for the problems, inspecting video segments, studying textual explanations that appear with visual representations, recording responses and notes, e-communicating with other students via the e-messaging system, participating in e-discussions, evaluating alternative viewpoints, playing e-games, and constructing and modifying arguments. The sample consisted of 234 students from ten different classrooms (6-8th grade) of three schools, one private and two state schools, which were selected based on the criterion of accessibility. In order to test the impact of the collaborative use of Argümantaryum under teacher guidance on development of conceptual knowledge and scientific discussion skills, the students in the five 6th grade classrooms were divided into two groups. The first group consisted of two classrooms of students (n=40) who used the platform individually without teacher guidance (IND), and the second group consisted of three classrooms (n=96) in which students used the platform collaboratively with teacher guidance (COL).

In addition, to compare the impact of the using Argümantaryum on those students who used it collaboratively under teacher guidance and those who studied the same learning unit with a teacher within a classroom based setting, the students of three 8th grade classrooms were divided into two groups, two classrooms (n=46) were assigned to the group that engaged in the collaborative use of the platform with teacher guidance (COL), and one classroom (n=25) was assigned as the group that engaged in conventional activities developed and directed by their classroom teacher. A final objective of the study was to test the Argümantaryum as an instructional tool. To this end, a seventh grade science teacher used the system to support her instruction of the unit entitled "Particulate Nature of Matter and Features" to seven students. Five different data collection instruments were used: (1) LOG files of the system which keeps record of user actions on each component of the systems, (2) Achievement Pre-tests and post-tests, (3) Test for scientific discussion skills, (4) a usability questionnaire, and (5) classroom observations of the teachers and researcher, and interviews with teachers and students. A Mann-Whitney U test was employed for data analysis purposes. The results revealed that students who had made collaborative use of the argumentation based multimedia science learning environment under teacher guidance developed better scientific discussion skills than those who had made use of the same platform individually without teacher guidance. The study also revealed that collaboratively studying students had made significant progress from pre- to post-tests on both unit achievement tests and tests for scientific discussion skills. However, results indicate no progress in either of the tests of individually studying students. As for the students in the control group, they performed much better at the post-test for scientific discussion skills. With respect to knowledge, results indicated that there was improvement in both groups' knowledge from pre- to post-tests. In conclusion, using of the argumentation based multimedia science learning environment collaboratively under teacher guidance had helped students develop more conceptual knowledge and better scientific discussion skills than using the same platform individually without teacher guidance. Even though both collaborative use of the system under teacher guidance and the lecture based activities had significantly helped students develop conceptual knowledge, it was found that the lecture based activities had helped to develop better scientific discussion skills. The students who had used the system individually without teacher guidance could not benefit from the system as much as the collaborative groups who had also received teacher guidance (Akpınar, Ardaç, & Er-Amuce, 2014).

Supporting and promoting argumentation

Researchers interested in exploring how students generate arguments within the context of science tend to focus on three issues: (1) the structure or complexity of the argument (i.e., the components of an argument), (2) the content of an argument (i.e., the accuracy or adequacy of the various components in the argument when evaluated from a scientific perspective), and (3) the nature of the justification (i.e., how ideas or claims are supported or validated within an argument). These issues shed light on the theoretical perspectives underlying the frameworks, the pedagogical or research goals of the researchers, and the constraints of each approach for studying the arguments that students construct in the context of science education. Furthermore, they can provide significant amount of information about students' understanding of scientific content, such as the theories, laws, and ideas that are important in science, scientific reasoning students engage in, their epistemological commitments, such as what they consider justified knowledge, and their ability to communicate and justify ideas to others (Sampson & Clark, 2008).

Studies report that students are weak in argumentation skills within the context of science (Driver, Newton, & Osborne, 2000). To illustrate, some studies have indicated that students tend to display unwillingness in rejecting preconceived conclusions, and instead, tend to manipulate or distort data (Berland & Reiser, 2009; Sandoval & Millwood, 2005; Walker & Sampson, 2013). It is claimed that those students who have not received training in constructing and assessing arguments tend to base their arguments on their own opinions, tendencies and pre-conceived notions (Aslan, 2014). Other researchers exploring the ways students construct a written argument have found that students are unable to distinguish relevant from irrelevant data and sometimes cannot even decide or understand what data can serve as evidence (Kelly & Bazerman, 2003; Walker & Sampson, 2013). This could stem from the fact that students may not be equipped with the necessary scientific knowledge or may not know how to convert their knowledge and experiences of the topic into evidence to support a claim (Aslan, 2014).

To illustrate, one research investigated how children made use of evidence in decision-making activities and whether they used evidence to justify their decisions (Maloney & Simon, 2006). Four collaborative decision-making activities were employed in the study to stimulate group discussion among five groups of four children (10–11 years old). The activities were designed in a way that students could be exposed to different opinions, which would enable them to reflect on their own reasoning and unveil their thinking process. Thus, the activities were designed taking into consideration children's interests; they included presentation of evidence in different formats (pictures, written information, artefacts, tables of data); and they provided alternative choices. During the discussions, the children made claims and expressed their views regarding their choices. As instruments of analyses, an analytical scheme was devised to determine the nature of collaboration and argumentation displayed by the five groups of children and a coding system was devised to show the different approaches to how they engaged in discussion. A system called “Discussion map” was devised in order to identify the nature and the degree to which children engaged in sustained argumentation dialogue. As a result of the study, it was observed that children aged 10–11 years were able to use information to justify and support their claims. However, the results showed that the number of claims supported by evidence showed variation. Children with less sophisticated reasoning skills were not influenced by the arguments of the other group members. By means of the activities implemented, it could be concluded that children’s skills in interpreting and evaluating evidence could be developed in different contexts. It was also observed that although all groups of children seemed to work cooperatively, they did not actually work collaboratively since some children arrived at decisions independently, which prevented them from reaching an agreement within the group. Thus, it was claimed that providing students with the opportunity to use argumentation may not be sufficient for them to make progress in the argumentation skills. This study showed that evidence was used more systematically and the level of argumentation was more sophisticated when children prompted each other by asking for reasons underlying their decisions. A conclusion that can be derived from this study is that providing children with activities where scientific evidence is discussed and teaching children to adopt the roles that maximize the use of evidence and argumentation skills can enhance children’s scientific reasoning skills and their understanding of scientific concepts (Maloney & Simon, 2006).

Studies show that students experience difficulty in supporting or providing a rationale in justifying their choice of using certain pieces of data as evidence in their written arguments (Bell & Linn, 2000; Walker & Sampson, 2013). From the way students evaluate justification, it is observed that students do not know the importance of justifications and the function they serve. This could be stemming from students’ lack of scientific knowledge, from experiencing problems in evaluating evidence, and from their lack of experience in coordinating their knowledge and establishing associations between claims and evidence (Aslan, 2014). For example, it was reported in a study by McNeill and Krajcik (2008) that the middle school students in the study had no problems in learning how to support their claims with evidence quickly; however, most of the time, they could not express the scientific principles that had enabled them to make that connection (Walker & Sampson, 2013). Being able to establish an association between claims and evidence is not solely a cognitive skill, showing that the data or the concepts underlying the claims have been understood. It is also a part of a broader social practice used to persuade other people. Therefore, students' explanations reflect their ideas about what makes an argument persuasive to a particular audience (Sandoval & Millwood, 2005). Studies also show that even when students have understood the concept of evidence, they present the evidence as all inclusive, neglecting to rationalize the use of this evidence in supporting their claim (Walker & Sampson, 2013). The main problem here may be that the way students could be organizing their knowledge in the way it that can justify the claim. This suggests that students are not exposed to environments of inquiry and thus, lack experience, in exercising questioning skills (Aslan, 2014).

In a study by Sandoval and Millwood (2005), which took place in four introductory high school biology classes taught by two teachers, the relations between students' conceptual understanding of specific domains and their epistemic understanding of scientific practices of argumentation as they tried to learn science through inquiry was explored. The analyses in the study were based on assessing the justifications provided by students for explanatory claims, the adequacy of the evidence that they explicitly cited for their claims, and their rhetorical use of specific inscriptions in their arguments. 87 high school students in an introductory biology class had participated in the study. For 4 weeks, each class was required to work concurrently on the same unit, the theme of which was evolution. The unit was centred around two week-long, computer-supported investigations of real cases of natural selection. During these investigations, students worked in groups of three or four collaboratively to explore large sets of data in the computer investigation environments and use them to explain each problem. The study yielded conceptually high quality arguments from the students. This suggested that students were quite successful in appropriating the scaffolds available in the learning environment to construct arguments that were consistent with the theory of natural selection. The students had been able to distinguish their claims from the data on which those claims were based. It was found that students had made reference to data without any interpretation. This could have stemmed from students' belief that data were self-evident and did not need explanation. If this is correct, then it reflects a sense in which claims are not distinct from data but that the data are somehow embedded into the claims that a particular graph or table or other inscription directly represents some aspect of the natural world and consequently has but one meaning. It was also observed that students had found it necessary to cite data, but the amount of evidence they had cited for the claims was insufficient. Finally, students' references to specific inscriptions in their arguments often failed to establish a connection between specific data and particular claims (Sandoval & Millwood, 2005).

Several studies have also revealed that many students believe that scientific results are objective-based discussions and, are thus undebatable, so they find it conflicting when asked to debate scientific claims (Kolsto & Ratcliffe, 2008). Consequently, in order to participate in inquiry and argumentation, students need to learn how to derive meaning out of arguments and develop an understanding of the social and cultural scientific practices (Clark & Sampson, 2007).

A study by Bell and Linn (2000) examined (i) the impact of Knowledge Integration Environment (KIE) activities on argument construction and (ii) the influence of views regarding the nature of science on this process. Middle school students participated in the Computer as Learning Partner and Knowledge Integration Environment (KIE) research projects. A total of 86 pairs of students, that is 172 students in total, carried out the activities for six class periods. During this time, students explored the topic of light by conducting experiments which involved the collection and analysis of real-time data. Working in pairs, students spent approximately six days reviewing evidence and constructing their arguments, which included explanations relating individual pieces of evidence, and categorizing the evidence into theoretical frames. During the construction of their arguments and the debate, students took into consideration the ideas of others and used them to refine their own ideas. Students were given 13 items of evidence, for which they were encouraged to develop an explanation. The students' interactions with the learning environment were studied to gain insight into how students engaged in the KIE activities and how they produced artefacts. Students were administered a survey which questioned their beliefs about the nature of science. It was observed that students participating in the debate had acquired a more normative and robust understanding of how far light goes. Most students had stopped producing descriptive or vague responses, while some had also stopped producing non-normative causal explanations. It was also observed that the frames students had created were beyond the curriculum materials. In other words, students had elaborated on their arguments using frames that were based on their own conjectures and categories for the evidence. One other finding of the study was that the explanations provided by the students generally relied on justifications but not supports, and students tended to conjecture rather than describe. The dominant use of justifications in student arguments indicated that students were not engaged in simple description of the evidence, but, instead, on attempting to adapt the evidence to the debate through scientific conjectures. The researchers hypothesize that the reason underlying students' omission of supports is their assumption that the audience already knows about them. Bell and Linn (2000), based on their study, maintain that engaging students in knowledge integration and argument construction improve students' understanding of the nature of science. They claim that students who view science as a dynamic process create more complex arguments and are less likely to use supports in their arguments. Their study showed that students who held a more sophisticated view of science as its being dynamic theorized more in their arguments by including more unique justifications and conceptual frames. Students who also viewed science learning as understanding concepts rather than memorizing facts were also aware of the importance of understanding scientific evidence from both sides of the debate (Bell & Linn, 2000).

It is reported in related literature that students may be uncomfortable evaluating and critiquing the claims of their peers and when they have to, they rarely use criteria that are valued in science (Berland & Reiser, 2009; Walker & Sampson, 2013). When students are posed questions to enable them to reflect on the justifications they have produced, it is observed that the justifications produced by students are based on memorized knowledge, not reflecting an in-depth perspective. This shows that students need practice and experience in understanding how phenomena should be evaluated and how knowledge can be used in different situations (Aslan, 2014).

A more comprehensive picture can be gained by means of a study by Albe (2008), which aimed to document the argumentation patterns students developed in small group discussions on a controversial socio-scientific issue. A micro-ethnographic approach was used to explore how students elaborated on their arguments. The study was carried out in an 11th-grade science class, composed of 12 students specialising in sciences and technologies for agronomy and the environment, in the context of vocational secondary education. The aim of the course was based on enabling students to understand how to assess the quality of scientific data. During the course, contemporary discussions were held about health effects associated with mobile phone use. In the first part of the lesson, students were required to examine the issues inherent in the controversy and the technological and scientific concepts involved. They were then trained to evaluate the validity and reliability of research results. Subsequently, students were asked to review a number of studies and to select those that supported a particular point of view. Then each group of students performed a role-play during which they acted as expert witnesses in a trial and presented their case giving arguments. Each group discussion was audio-taped and students' discourses were fully transcribed. The content or the discourses were then analysed employing a micro ethnographic perspective. The data were analysed at different levels. First of all, timeline maps were built. Then, the transcriptions of the students' discourse were examined (i) to explore how arguments were constructed within and across the two discussion groups, (ii) to identify the content of the arguments and (iii) to explore the factors that influenced argumentation within the groups. The findings of the study yielded several processes of group argumentation. It was observed that students' arguments were elaborated from scientific data, common ideas and epistemological and strategic considerations. On the other hand, technological and scientific knowledge had played a small role in students' argumentation. It was found that students' social interactions had also influenced the patterns of argumentation elaborated within the group discussions. That is, the social roles assumed by the students in the group had an impact on their collaborative argumentation. Students had displayed their capability of expressing and countering arguments when discussing the controversial danger of mobile telephones. However, counterarguments had been expressed without elaborate explanations or alternative proposals, which could cause the destabilisation or the abandoning of the issue under discussion. The two groups of students had engaged in different processes of argument co-elaboration. The group that claimed that there was a danger (Group A) produced more arguments than the opposite group. Moreover, when the discursive practices in the discussion groups were analysed, it was observed that the students in Group A had developed more collaborative argumentation episodes than the other group. It was found that students were able to resolve disagreements through discussion when they were related to strategy, argument formulation and text interpretation; however, when they concerned epistemological requirements, these disagreements led to the fragmentation of the discourse objects. One other result obtained concerns expression of opposing views. When students expressed opposing views, it rarely allowed further justifications. When they questioned others' positions or introduced alternative proposals, it raised other oppositions. In the study, it was also observed that processes of collaborative argumentation occurred most of the times between two students within group discussion. In line with findings of other studies, this study also reports that naive epistemological representations may limit argumentation (Albe, 2008).

Another crucial problem that emerges within the context of argumentation development in the science classroom stems from the power relationship between the science teacher and the students. It is reported in related literature that if the teacher assumes an authoritarian and dogmatic approach to the discipline and seeks to establish a consensually agreed-upon scientific worldview, then there would be not much space for dialogic discourse within the classroom (Osborne, Erduran, & Simon, 2004; Duschl & Osborne, 2002).

To illustrate, a study by Larrain, Freire, and Howe (2014) aimed to describe the extent to which argumentative discourse was spontaneously used in middle-school science teaching and aimed to present a panoramic view of the frequency of dialectic argumentation as opposed to one-sided argumentation. Another concern of the study was to seek whether there was any relationship between teacher performance and students' grades. Thus, the research questions the study sought to respond to were as follows: (1) How much time on average do teachers and students spend on dialectic argumentation, one-sided argumentation or other type of non-argumentative discourse? (2) Who is involved in each type of argumentative discourse? (3) What are the epistemic characteristics of argumentative discourse, and specifically, which conceptual level predominates in argumentative discourse? (4) Does argumentation occur differently according to teacher performance? (5) Does argumentation use in science teaching vary according to grade? The context was science instruction in a Chilean middle-school. From a total of 918 fifth-grade (10–11 years) and seventh-grade (12–13 years) science teachers who participated in the Chilean national system, 153 teachers were randomly selected to participate in the study. Of the sample, 69 were fifth-grade teachers (46 female), and 84 were seventh-grade teachers (54 female). The study used videotapes of lessons from science teachers' portfolios (one lesson of one teacher per video) for data collection. The findings of the study indicated that argumentation in the observed lessons occurred predominantly between teachers and students, but the teacher had control over the argumentation process. In addition, based on the descriptive analysis of episode codes, it was found that on average there was no use of argumentative discourse in 50.97% of the lesson time coded. It was observed that more time was devoted to dialectic argumentation in lessons of teachers who had displayed better teaching performance, despite the mean duration still being short. Results suggested that argumentative discourse in which contradictory points of view were discussed was scarce, but when it did take place, it did so predominantly within discourse among students. On the contrary, argumentation aimed at justifying claims was found to be widely used, especially among older students. However, dialectic argumentation was found to be scarce in routine lessons. In contrast to previous research, the study reported that more widely conceived argumentation played an important role in science teaching. The student's voice seemed to be only seriously considered in a carefully structured task which involved teacher–student interaction. Students' counter-opinions and argumentative questions were not systematically related to teachers' argumentative utterances. As for the relations with teacher performance, teachers with higher scores had classrooms that achieved higher numbers of episodes involving counter-opinions and responses (Larrain, Freire, & Howe, 2014).

It is postulated by Sampson, Grooms, and Walker (2011) that the development of the knowledge and abilities to participate in scientific argumentation and to produce written arguments necessitates much more than grouping students together and asking them to develop an evidence-based argument or explanation for a natural phenomenon. The required knowledge and abilities is complex entailing an inherently social and epistemic process as well as a conceptual and cognitive one (Sampson, Grooms, & Walker, 2011).

A study by Kim and Song (2006) explored the features of peer argumentation in middle school students' scientific inquiry. The participants consisted of two boys and six girls in grade 8 of a middle school, where students engaged in open inquiry activities in small groups. Each group prepared a report, which was later reviewed by their peers. Subsequently, students were guided to construct written arguments. One finding of the study was in relation to the stages the students went through in their critical peer discussion. It was observed that they proceeded through four stages: Focusing, Exchanging, Debating and Closing. Another finding concerns the type of evidence they used. 75.6% of the evidence used in students' arguments was found to be based on personal evidence. It was also found that students used various cognitive strategies, such as questioning, elaboration, clarification, using analogy, hypothesising, and authorisation. However, they also used social strategies for inducing conflict (e.g. unspecified criticism, repetition, cutting short, challenging and muttering) as well as for inducing cooperation (e.g. negotiation, change of a topic, change of atmosphere, suggestion and explicit closing). In conclusion the study showed that for an effective critical discussion, making good use of the focusing stages mentioned was important. It also showed that constructing arguments for defending and supporting claims against a peer's critique enabled students to think reflectively (Kim & Song, 2006).

In summary, the available literature suggests that students' lack of competence in argumentation skills in science does not indicate that students have low cognitive abilities or poor argumentation skills. Rather, it shows that they misunderstand the essence of science (Walker & Sampson, 2013). This is believed to be stemming from the fact that students do not understand the goals and norms of scientific argumentation and how these goals and norms are different from the forms of argumentation they are familiar with, not from a lack of skill or mental capacity (Sampson, Grooms, & Walker, 2011). Aslan (2014) postulated that students possess great amounts of scientific knowledge, but they do not have sufficient experience in coordinating this knowledge and presenting this knowledge as components of an argument. The importance in having the ability to evaluate claims in the context of science is frequently cited in related literature (Sampson & Clark, 2009). On the other hand, numerous studies on scientific argumentation suggest that this ability does not come naturally to most individuals but is acquired through practice (Osborne, Erduran, & Simon, 2004; Walker & Sampson, 2013). Thus, there is a need to explicitly teach the argument discourse by means of appropriate instruction, tasks and modelling (Osborne, Erduran, & Simon, 2004). Modelling effective arguments in science facilitate the teaching of argumentation because it enables students to understand the criteria used for judging (e.g. parsimony, comprehensiveness and coherence) why some arguments are considered better than others (Duschl & Osborne, 2002). Since solely presenting students scientific or controversial socio-scientific issues to discuss is not sufficient to ensure the practice of valid arguments (Osborne, Erduran, & Simon, 2004), there is a need for students to be explicitly taught how to construct an argument with its claim, evidence and rationale (Jiménez-Aleixandre, 2008; Walker & Sampson, 2013).

Hence, some features that researchers have identified of learning environment supporting scientific argumentation and which need to be taken into account can be itemized as follows: (a) students should engage with plural accounts of phenomena and evidence to support multiple points of view, (b) the learning environment should provide a context that fosters dialogic discourse, (c) tasks and activities given to groups should require collaboration in order to promote discourse between students, (d) students should be allowed enough time to understand the central concepts and underlying principles, and (e) the teacher or learning environment should facilitate student-to-student talk without the limitations of most teacher–student interactions(Duschl & Osborne, 2002).

A case study by Jiménez-Aleixandre, Rodriguez, and Duschl (2000) focused on students' capacity to develop and assess arguments during high school genetics instruction. The overall purpose of the study was to report on the conversational dynamics in the form of argumentation patterns and epistemic operations that students employed while solving a problem in the science classroom. More specifically, one goal of the research was to gain insight into the discourse patterns students employed in their discussion groups in terms of the "doing school" vs. "doing science" perspective. Another related goal was to develop an in-depth understanding of how curriculum, instruction, and assessment models should be designed to promote and facilitate students' self-monitoring skills in scientific reasoning and meaningful participation in doing science. Participants of the study were a class of high school (9^{th} grade) students in Galicia (Spain). Students were observed, videotaped, and audiotaped while carrying out group work throughout six class sessions. As for the procedures of the study, first, the researchers tried to reveal whether students were "doing the lesson" or "doing science". "Doing the lesson" refers to instances when the classroom discourse is dominated by displaying the roles of students and "doing science" refers to discourse dominated by talking science. For instances of "talking science," two analyses were conducted. The first was related to the argumentative processes in the discourse, and the other was related to the epistemic operations. To analyse students' conversation, Toulmin's argument pattern was employed as a tool. Other frameworks were used to analyse other dimensions of the dialogues students produced (e.g., epistemic operations, use of analogies, appeal to consistency and causal relations). The study reports that a significant part of the dialogues among students could be described as belonging to the school or classroom culture as interactional procedures which can be considered as doing a lesson, but are not necessarily related to the stated goals for learning. On the other hand, there were instances where reference to school culture was less explicit and referred not to a particular rule, but to the perceived features of classroom or lessons. As discussions proceeded, students referred more to the science issues and less to rules or to incidental talk. When the different arguments constructed by students were examined, it was observed that the elements of the arguments, and the sequence revealed that the arguments predominantly contained claims and were weak in justifications. The analysis also showed that the students had developed a variety of arguments, in which some were more sophisticated (with justifications) than others. On other hand, most of the time, the claims were made without any relation to other elements in the argument. In almost all the arguments, the backings were existent only implicitly (Jiménez-Aleixandre, Rodriguez, & Duschl, 2000).

Kuhn and Udell (2003) sought to obtain experimental evidence to support cross-sectional patterns of development in argument skills and to evaluate the effectiveness of an intervention designed to foster development of these skills in 13- to 14-year-olds, who were academically at risk. The main concern of the study was the discourse of the arguments produced by the participants. In particular, the study aimed to look into whether developmental trends in discourse patterns identified in the study were consistent with the earlier ones reported in literature. The study also aimed to examine the role of argumentative discourse in the change observed in participants' argumentation skills. The participants of the study were comprised of 34 academically at-risk 8th grade students in two low-performing, inner-city public middle schools in New York City. As for the procedures followed in the study, first of all participants' initial opinions were assessed and based on whether they were for or against the issue, they were assigned to either the pro or con team. Then they carried out a 16-session activity that was goal-based, required collaborative work and dense argumentation thinking. The goal of the activity was to enable students to move away from exposition and move towards engaging in dialogue devoted to challenge. The analyses of the arguments were based on three aspects of the argumentation skill: (1) the amount of different reasons a participant possessed as potential components of an argument, (2) the quality of the arguments produced by the individual, and (3) the quality of the argumentative discourse a participant produced in the dialogues with his/her peers. The results of the study revealed that participants showed increased frequency of using powerful argumentative discourse strategies, such as counterargument, and decreased frequency of less effective strategies. Improvement was observed not only in the quality of individual arguments but also in their argumentative discourse skills (Kuhn & Udell, 2003).

In the study carried out by Schwarz, Neuman, Gil, and Ilya (2003), the focus was on construction of knowledge through argumentative activities on a controversial issue. The design of the study was quasi-empirical. The participants of the group were 120 fifth grade students. Some of activities implemented in the study required individual work, while others required working in collaboration. First, students were administered a questionnaire in order to understand their individual standpoint regarding the issue. Subsequently, two groups of triads were formed to engage in argumentative talk. In the first group (G1, N1 = 60), triads used the argumentative map, which was a computerized tool, to represent viewpoints and reasons supporting these viewpoints. In the second group (G2, N2= 60), triads completed a table by inserting “pro and con” reasons. After this initial task, the triads were required to write a collective essay summarizing their common viewpoint. The analysis procedures consisted of measuring the construction of knowledge through arguments produced by the participants. Four measures were identified to characterize the properties of the arguments: (1) the argument type, i.e. whether the argument was one-sided, two-sided, or compound; (2) the soundness of the argument, i.e. whether the reasons claimed to support the argument were acceptable and relevant to the standpoint; (3) the number of reasons raised to support alternative stand points; (4) the quality of the argument, as reflected in the number of abstract reasons included in the argument. Construction of knowledge by individuals and groups was examined through the changes in these measures during the successive activities. Tools for evaluating changes in individual and collective arguments were developed. Results of the study indicated that all measures of individual arguments had increased during the successive argumentative activities. More specifically, individual arguments had become less one-sided and more compounded. In addition, not only were there more reasons supporting alternative arguments but the reasons produced were also more acceptable and relevant to the standpoint. Finally, the quality of the reasons expressed had increased. In other words, reasons were less vague or personal and more abstract. When the arguments produced individually and those produced collectively were compared, the latter yielded higher measures than the individual arguments according to the four measures. The significant differences between collective and individual arguments suggested that individual students had only partly internalized the collectively constructed arguments (Schwarz, Neuman, Gil, & Ilya, 2003).

One other important principle in teaching argumentation is cited as allowing learners to have sufficient time to understand the central concepts and underlying principles (e.g., the 'facts') important to the particular domain (Duschl & Osborne, 2002). That is, students need to have knowledge of the 'facts' of a field in order to produce good arguments. Otherwise, they will not be able to produce evidence for the claims they make. Thus, students also need to develop strategic and procedural knowledge skills that are required in constructing arguments (Duschl & Osborne, 2002).

One solution proposed in literature is the employment of new instructional models that create more opportunities for students to develop the understandings and abilities needed to participate in scientific argumentation (Sampson, Grooms, & Walker, 2011). To this end, some science educators, such as Simon, Erduran, and Osborne (2006), have designed sets of activities that, they believe, can help people learn to produce arguments in science and how to participate in scientific argumentation. Other science educators, such as Sandoval and Reiser (2004), have tried to place a more central focus upon argumentation during inquiry-based instruction.

A study by Simonneaux (2001) explored the impact of two types of activities, namely role-play and conventional discussion, on students' argumentation on an issue involving animal-trans genesis. The participants of the study were two classes of students in their 2nd year of upper secondary vocational education geared to scientific subjects. As part of the study, first students were presented a fictional situation. Within this fictional situation they were required to decide whether or not to approve a giant transgenic salmon farm that was being set up in a seaside village. To arrive at a decision, they had to act out the roles of people taking part in a public debate organized by the Mayor. Students went through the same process for the conventional discussion or debate situation. Students were asked to reach a decision on well-argued grounds, to identify areas of uncertainty and to define the condition or conditions under which a change of view might be considered. They had to write them down. Pre- and post-tests were used to assess the students' opinions. The role-play and discussions were all video- and audio-taped and transcribed completely. The analysis focused on the argumentative structure of the students' discourse and identified the reference areas that students draw on to deliver their arguments. The theory of economics of 'greatness' or 'importance', a recently emerged framework for the sociology of justification, was also used in analysing students' discourse. This theory, which is sometimes called 'economics of consensus' or 'sociology of justification' is based on the notion that there are several 'worlds' in which action takes place and where people resort to various skills to cope with their endeavours. This implies that human actions are structured around principles of justification, commitment and criticism. The crucial point in justification processes is the 'orders of importance' that are attached to objects of debate. Agreement between those involved in a debate becomes possible when there is a 'consensus' on these 'orders of importance'. As for the findings, the study reported few significant differences between the arguments presented by the students in each activity (role-play and debate). The researchers claimed that among all the studies they had previously conducted, this was the first in which they observed changes of opinions. They reported that three students had changed their mind after the role play and four had done so after the discussion. The main problem concerning the role-play was the teachers' lack of familiarity with role-play practice. On the part of the students, they found it difficult to use the information appropriately in accordance with the description of their roles. The major problem experienced in the discussion was the reservation of some students. Although they were asked several times for their opinions, seven students did not take part in the debate. The researchers concluded that the didactic strategy involving role-plays or class discussions seemed to be a useful way of helping students to develop their arguments (Simonneaux, 2001).

Osborne, Erduran and Simon (2004) sought to determine the extent to which lessons that follow these pedagogical strategies lead to enhanced quality in students' arguments. To this end, the study was conducted in two contexts: a socio scientific context and a scientific context. The lasted two years. The participants of the study in the first year were 12 junior high school teachers, who were required to explore and develop their practice at initiating argumentation in the classroom, and the participants in the second year was consisted of a subset of 6 of these teachers to explore the effect such activities had on the classroom discourse and students' use of argument. Data sources included the video and audio transcripts of the discussions held by students and the transcriptions of the interviews held with the teachers at the beginning of each year. As a tool of analysis, the analytic framework developed by Toulmin (1958) was employed. The results of the study illustrated several features of the nature of the discourse in these lessons. First, a significant shift from the authoritarian dialogue to argumentative discourse was observed at the end of the intervention. Secondly, it was observed that there was less argumentative discourse for argumentation in science lessons than there was for socio scientific lessons, suggesting that initiating argument in a scientific context is harder and more demanding both for students and their teachers. Third, findings also indicated that there was little difference in the amount of discourse between the experimental groups and the comparison groups, suggesting that the amount of argumentative discourse depended on the teachers' structuring and organization of the lesson rather than any characteristic of the student groups. The researchers concluded that the results of the showed evidence of positive improvement in the quality of student argumentation, but the change was not significant, which could be attributed to the fact that the development of the skill and ability to argue effectively is a long-term process. Another conclusion that they have arrived at is that supporting and developing argumentation in a scientific context is significantly more difficult than enabling argumentation in a socio scientific context (Osborne, 2005; Osborne, Erduran, & Simon, 2004).

Sandoval and Millwood (2008) was cited another instructional model experimented in their study. The study was conducted in a Grade 7 classroom in an urban middle school in Los Angeles. The participants of the study consisted of 33 students (20 boys, 13 girls) and their teacher. Students' ideas about justifying claims within the context of a three-week science unit called Sensing the Environment were explored. The procedures of the study involved the presentation of unit and then followed a series of laboratory activities. The last step in the procedures was an investigation that students carried out on a specific topic related to the unit using an online environment. Findings of the study indicated that the majority of the students had expressed all of the claims, but most students had not provided justifications for their claims. Another finding of the study concerns students' notions of empirical warrants. More than half of the students had claimed that empirical warrants were how they knew they were certain of their claims, although fewer than 25% of them cited any evidence for their claims (Sandoval & Millwood, 2008).

Argument-Driven Inquiry (ADI), which is a specific instructional model, was developed and experimented in a study by Sampson, Grooms, and Walker (2011). The overall aim of this study was to investigate how ADI impacted the ways students participated in scientific argumentation and produced written arguments. The ADI instructional model is rooted in social constructivist theories of learning and its goal is to function as a template or a guide that science teachers can use to design more authentic and educative laboratory activities. The ADI instructional model is similar to other approaches in that it is designed to change the nature of a traditional laboratory instruction so that students can be provided with to learn how to develop a method to generate data, to carry out an investigation, use data to answer a research question, write, and be more reflective as they work. However, what is different in the ADI instructional model is that it also provides an opportunity for students to participate in other important scientific practices such as scientific argumentation and peer-review during a laboratory session. The researchers believe that it is through the combination of all these activities that students can begin to develop the abilities needed to engage in scientific argumentation, understand how to produce written arguments, and learn important content as part of the process (Sampson, Grooms, & Walker, 2011).

To evaluate the model, a performance task was employed to assess how six small groups of students participated in argumentation and produced written arguments before and after an 18-week intervention(Sampson, Grooms, & Walker, 2011). The intervention lasted one semester and the implementation of the ADI instructional model consisted of seven components or steps: (1) the identification of the task by the classroom teacher, (2) the generation of data by means of students' collaborative work to develop and implement a method to address the problem or to answer the research question posed during the first step of the model, (3) the production of a tentative argument, (4) implementation of an argumentation session where the small groups share their arguments with the other groups and critique the work of others to determine which claim is the most valid or acceptable, (5) the creation of a written investigation report by individual students, (6) a double-blind peer review of these reports to ensure quality, and (7) the revision of the report based on the results of the peer review (Sampson, Grooms, & Walker, 2011).

The participants of the study consisted of nineteen 10th-grade students (7 males, 12 females, average age = 15.4 years) enrolled in the same class (23 students in total) of a chemistry course (Sampson, Grooms, & Walker, 2011). These participants were randomly assigned to one of six groups. For the analysis of the data, a performance task was employed to assess how the students participated in scientific argumentation and produced scientific arguments. Subsequently, coding schemes were developed to assign a score to indicate the quality of the written arguments produced by each group before and after the intervention and to document any potential changes in the ways students participated in scientific argumentation. The findings of the study demonstrated that these students were more competent in or more willing to engage in argumentation after participating in the 15 laboratory experiences designed using the ADI instructional model. It was also found that these students were challenging each other's ideas and claims more frequently after the intervention. Thus, after the intervention, the students seemed to be much more comfortable with oppositional discourse, which is an important characteristic of better argumentation. Another finding was related to the way students engaged in argumentation. The manner they assumed to engage in argumentation reflected the discipline of science more appropriately after the intervention. Finally, in general, students seemed to adopt and use more rigorous criteria to distinguish between explanations and to justify or evaluate ideas as a result of the intervention. The greatest improvement was observed in the quality of the evidence and the sufficiency of the students' reasoning. However, reason underlying this improvement was attributed the students' lack of familiarity with the nature of scientific arguments at the beginning of the semester rather than a lack of skill or natural ability. In conclusion, it is believed by the researchers that as a result of the intervention, students were able to develop a deeper understanding of the various components of a scientific argument and learned how to produce a better scientific argument over the course of the semester by participating in the 15 ADI lab experiences (Sampson, Grooms, & Walker, 2011).

ADI was compared with more traditional approaches to instruction (Walker, Sampson, Grooms, Anderson, & Zimmerman, 2012). More specifically, the impact of ADI was explored to find out whether there was improvement in students' understanding of content, argument skills, and attitudes toward science. The context in which the study was conducted was 16 laboratory sections of an introductory college chemistry course. A total of 186 students participated in this study. Data was collected before and after the intervention to address students' conceptual understanding of chemistry, their ability to use evidence and reasoning to support a conclusion, and their attitude toward chemistry. Conceptual understanding was measured by means of the Chemical Concept Inventory (CCI), a multiple-choice exam designed to address student conceptual understanding rather than factual recall. Performance-based assessments were used to elicit written arguments from students, which were then evaluated in terms of ability to use evidence and reasoning to support a claim. Finally, a survey instrument was employed to measure student' attitudes toward science. Six of the seven investigations of the ADI were implemented in the study. On the other hand, in the traditional lab sections, 11 different investigations were implemented. The topics of the ADI investigation were identical to 6 of the 11 topics treated in the traditional Labs. Students in the traditional labs were required to follow a step-by-step procedure, to fill out a data table, and to answer a set of analysis questions during each investigation. Analysis of the data based on the difference between pre- and post-intervention scores on the CCI test showed that the students in both the traditional lab sections and the ADI lab sections had developed a better conceptual understanding of the content over the course of the semester even though the ADI group had completed fewer investigations. The analysis also showed that students in the ADI lab group were able to use evidence and reasoning to support a conclusion better than the traditional lab students. It was observed that ADI students had provided more evidence and had used evidence to justify claims more effectively than did students enrolled in the traditional laboratory sections. Finally, the results indicated that at the end of the semester, students in the ADI labs generally had a more positive attitude toward chemistry than did the traditional lab students. Based on the findings of the study, the researchers maintain that the ADI instructional model provides opportunities for students to engage in a wide range of activities, such as the generation of an argument, the discussion of findings, and the writing and editing of manuscripts in addition to experimental design and data analysis. They believe that extended engagement with an investigation in the context of ADI seems to promote not only conceptual understanding but also additional positive outcomes not realized by traditional laboratory instruction (Walker, Sampson, Grooms, Anderson, & Zimmerman, 2012).

Grooms, Sampson and Golden (2014) aimed to investigate whether or not students who developed robust skills in scientific argumentation through argument-based instruction were able to transfer those skills and habits of mind from the scientific context in which they were developed to an SSI-based context. The study assumed a quasi-experimental, pre- and post-intervention design. The sample of the study was comprised of two groups of undergraduate chemistry students. The intervention implemented in the treatment group (N=73) was a chemistry laboratory course aligned with the argument-driven inquiry (ADI) instructional model, while the comparison group of students (N=79) experienced the same course following a more traditional laboratory approach. The ADI model integrated into the treatment emphasized scientific argumentation, group collaboration, and peer review. The traditional approach employed in the comparison group was based on using a more ‘cookbook’ style, where the students were provided with the steps needed to complete each investigation and typically worked individually. Even though the same number of investigations was conducted by the comparison and treatment groups, the ways the students proceeded with the investigations varied. The steps to follow were made explicit to the students in the traditional course (comparison group), while the ADI students (treatment group) developed their own investigation procedures. In addition, different from the ADI students, the comparison group students were not given the opportunity to critique the work of their peers and argue about each other’s claims, nor were they able to participate in peer review. Each group of students completed the same two SSI tasks at the beginning of the semester (during the first week of class) and again at the end of the semester (within the last week of class); there were 13 weeks between pre- and post-data collection for each group. Findings of study indicated that the ADI students who had undergone the argument-based instruction generated significantly better arguments than students in the traditional course after the intervention. More specifically, the students in the treatment group were more successful in their ability to include rationales in their arguments supporting their stance on the SSI task. After the intervention, the students within the ADI treatment group had begun to display a more scientific habit of mind. They included rationales in their arguments more often than the students in the traditional group. However, despite improvements in argument structure, it was observed that the students participating in this study did not resort to scientific or empirical justifications to support their stance within the SSI tasks. Even though they were able to transfer characteristics of argument structure between the two tasks, it was found that the students had not made use of their science content knowledge as a justification to support their viewpoint within the SSI contexts. Based on these findings, it is suggested that justifying scientific arguments and socio-scientific arguments take place within different contexts. However, the use of instructional strategies grounded in scientific argumentation does seem like a useful approach in enhancing the structure of students’ arguments in the context of SSI (Grooms, Sampson, & Golden, 2014).

A final study on ADI, which is worth mentioning, is a study by Sampson, Enderle, Grooms, and Witte (2013), which examined how students' science-specific argumentative writing skills and understanding of core ideas changed over the course of a school year, during with they participated in a series of science laboratories designed using the ADI instructional model. The intervention was implemented for two semesters and consisted of at least eight laboratory activities in each course. The contexts of the study were the life science course (seventh grade), physical science course (eighth grade), biology course (9th or 10th grade), or chemistry course (10th or 11th grade) offered at a K-12 university laboratory school. A total of 294 students voluntarily participated in this study. The assessment procedures of students' learning gains were measured by means of a science content assessment and a science-specific argumentative writing assessment that were administered at the beginning, middle, and end of the school year. The procedures implemented in the study can be itemized as follows: 1) the students were provided with a small amount of background information and a related data table followed by a prompt which presented an argument by a scientist. 2) The students were required to refute the scientist's claim using information and data provided in the question. 3) The students were asked to support a counterclaim using evidence and a rationale. As a result of the analysis, it was found that the students who were enrolled in the life science course and the biology course had made significant improvements in their writing skills from pre- to midyear and then again from mid- to post year. These results are believed to suggest that the students in these courses made continuous improvements in their science-specific argumentative writing skills over the duration of the course. However, the students enrolled in the physical science course and the chemistry course had made significant improvements only during the first semester of instruction. The lack of improvement in writing scores during the second semester also corresponded with decreased opportunities to write in these two courses.

The analysis also showed that the content of the arguments (i.e., quality of the reasons provided, interpretation of the available data, and the use of language that was consistent with the norms of science) produced by the students at the end of the school year was significantly better than it was at the beginning of the school year in all four courses. Improvement was also observed in the ADI students' understanding of important science content and their ability to write in a scientific manner over the course of a school year. On the other hand, all the students in all four courses, had made significant learning gains as measured by the content assessment, which involved students describing core scientific ideas, such as natural selection or density, and producing explanations for different scenarios using those ideas. Moreover, all the students who participated in this study significantly improved their science-specific argumentative writing skills, which were measured by an assessment that required students to produce a counterargument using the same data and information employed in supporting an erroneous claim from another scientist. These findings regarding improvements in the students' assessment scores suggest that the various tasks and activities that are embedded in the ADI instructional model can help improve students' understanding of science content and their science-specific argumentative writing skills (Sampson, Enderle, Grooms, & Witte, 2013).

In sum, the research on argumentation from different perspectives demonstrated not only the interest to argumentation in science education research but also the contributions of argumentation to science teaching and learning as well as the efforts to make argumentation a part of science education. The research reviewed point to the fact that the integration of argumentation is not an easy task but requires understanding of argumentation as a crucial component of science education and a pedagogical approach to science teaching. When students are provided with argumentation related technology, or educational materials and are taught argumentation as a scientific practice, the results are promising both in terms of conceptual, practical and inquiry-based science learning and in terms of creating a social collaborative learning environment, in which differences are valued and respected. However, the lack of theoretical and pedagogical knowledge of teachers is the main difficulty in achieving these results in science lessons, because the research showed that students are provided few opportunities to experience argumentation (Driver, et. al, 2000; Newton, et al., 1999; Zeidler, 1997).

There are also attempts in Turkey to integrate argumentation in science classes. For example, there are innovations in the curriculum addressing argumentation (MNE, 2013), and there are research and development projects aimed at the professional development of teachers in argumentation practices (Günel & Tanrıverdi, 2012). The integration of argumentation in curriculum is a step to take but the teacher education remains its importance. In the following section, the attempts reflected in the science curriculum in Turkey to integrate argumentation were demonstrated.

3.2.3. Science Curriculum and Argumentation in Turkey

In Turkey, there are two science curricula currently in use. The Science and Technology Curriculum for elementary grades was initiated in 2004 (MNE, 2006). The goal of the curriculum was stated as promoting scientific literacy. The definition of scientific literacy made by the curriculum encompasses a wide range of abilities including the ability to make evidence based decisions, where individuals consider possible threats, benefits and alternative solutions related to scientific and socio-scientific issues (MNE, 2006). This part of the definition could easily be connected to argumentation although it is not explicitly stated in the curriculum, because the definition of argumentation involves the consideration of plural alternatives for judgment and decision making based on empirical or theoretical evidence. Therefore, argumentation whether as a scientific discussion, academic discussion or evidence-based judgment is given place in the curriculum.

The section related to teaching methods in the curriculum specify in particular the role of the teacher in argumentation. Specifically, the teacher is expected to encourage students' argumentation and evaluation of alternative ideas; to mediate debates and activities in a way so as to allow for the possibility of students' own constructions of scientifically accepted views and mind-sets, and to encourage students' skills in generating hypotheses and alternative interpretations in explaining phenomena (MNE, 2006).

According to Jiménez-Aleixandre and Erduran (2008), the work on argumentation is reflected in the following two standards which aim to help students (a) gain skills in research, reading and debate whereby learners are involved in new knowledge construction; and (b) understand the nature of science and technology as well as the relationship between science, technology, society and environment.

The science and technology curriculum proposes the interplay among different components of scientific literacy. One of these components is the understanding of the nature of science. While describing what is meant by nature of science, it was stated that in the investigation of scientific knowledge, students need to experience dialogic nature of argumentation and try to persuade each other (MNE, 2006).

The use of argumentation in science and technology curriculum is reflected in argumentation based on observations, about socio-scientific issues where students are asked to make decisions, about scenarios where probability of consequences of an action is questioned, and during experiments where they need to construct hypotheses, and decide to the actions they will take to test their hypotheses.

For example, in grade 6, one of the suggested argumentation is about the cells. After observing cell structures, students are asked to discuss whether all living cells have the same cell structure. In this example, students need to construct arguments about why or why not all living cells could have the same structure. While arguing, students need to find evidences from sources such as their observations via microscope, and their observations of the nature. Therefore, a good scientific argumentation can take place where students learn how to use evidences to justify their claims:

> "Students draw what they expect to see in the microscope. Then, they divide the onion membrane into three pieces and place them on separate

> object slides. By means of a dropper, they are asked to drop one drop of water onto the first piece of membrane, one drop of black ink on the second membrane, and one drop of green food colour or methylene blue on the third piece of membrane. They cover the slides and place them under microscope. They record their observations on a table and draw a picture of what they see on a paper. At the end of this experiment, teacher asks 'Do you think that all living beings have cells that are in the same structure of the ones you see in the microscope?' and initiates a discussion." (Researcher's translation) (MNE, 2006, p. 89)

Argumentation in socio-scientific issues is also suggested in elementary grades, such that students are asked to argue about water supplies. The argumentation about this question might raise the awareness of students on their knowledge of the water resources, as well as give them opportunity to think alternative solutions to a problem.

> "Students work on a world map or a world model to locate the hydrosphere (ocean, sea, lake, river, etc.). Then, they discuss which underground water supply (mineral water, hot and cold underground water, thermal water, etc.) and surface water supply are located in their neighbourhood. Under the guidance of the teacher, the classroom engages in discussion about how we can make use of the water in sea, lake and rivers in Turkey." (Researcher's translation) (MNE, 2006, p. 183).

An example of argumentation through a scenario is about the food chains in grade 7. Students are asked to think about the consequences of absence of an organism in the food web (MNE, 2006, p. 267). The argumentation on this scenario might not only reveal students' conceptual understanding of the food web and the role of each organism play in the food web, but also foster students' ability of critical thinking and decision making.

Argumentation during experimental work is mainly emphasized in higher grades. For example, in grade 8, students are usually asked to argue about the possible results of an experiment, and to make evidence-based judgments based on their data or observations. One of the examples is about the transformation of electrical energy to heat energy (MNE, 2006, p. 366). Students are given the question of what they can do to increase the amount of heat energy produced by an electric source. When the inquiry is performed by argumentation as suggested in the curriculum, students would reconsider their previous knowledge, discuss plural alternatives to the solution of the problem and use their data to construct their scientific claims.

The Science Curriculum, which has been in use since 2013 (MNE, 2013), incorporates crucial changes about argumentation. For example, the term argumentation was used explicitly in this curriculum and the teachers were encouraged to employ argumentation as a teaching strategy in the teaching of science in elementary grades. In the Science Curriculum, inquiry process is conceived not only as “discovery and experimentation”, but also as “explanation and argumentation” process. Students are expected to construct strong arguments based on sound justification regarding natural and physical environment. Teachers are responsible to involve students in dialogues, which incorporate students’ varied justifications in support of their claims and construction of counter-arguments to refute the oppositions. Moreover, teachers are expected to be guides in students’ spoken or written argumentation by encouraging them to present their claims based on valid data and sound justifications:

> “According to Science Curriculum, in the planning and implementation of the lessons, the learning environments (problem-based, project-based, argumentation-based and collaborative) are adopted to ensure students’ active participation and teachers’ guidance… The inquiry process is considered not only as “discovery and experimentation” but also “explanation and argumentation” construction process. The inquiry-based learning is a student-centred approach, in which students are educated as individuals, who are willing to discover everything around them, construct strong arguments based on sound justification regarding natural and physical environment, are enthusiastic about science and value science. In other words, the students construct knowledge in their own minds by doing-living-thinking just like a scientist. Teachers ensure the existence of dialogues, through which students express their ideas freely, provide varied justifications in support of their claims, and construct counter-arguments to refute the oppositions. Teachers are guides in students’ spoken or written argumentation with counter-arguments by encouraging them to present their claims based on valid data and sound justifications.” (Researcher’s translation) (MNE, 2013, p. III).

The Science and Technology Curriculum and the Science Curriculum for elementary grades is rich in terms of the opportunities for argumentation. The only weakness of these curricula in supporting argumentation is that they do not involve any guidance for teachers to help them implement argumentation in their classrooms. Teachers are only suggested to start and guide the argumentation but they are not told how to do it. The curricula assume that argumentation could easily be brought and directed by science teachers to support teachers in their teaching practice about the argumentation, curriculum might provide specific guidelines for teachers, such as the possible solutions to the problems, what to do in the presence of plural solutions, how to resolve conflicts, how to direct argumentation process in the presence of competing answers, and so on..

3.2.4. Problem Statement

In overall, the main point I wish to make is that, to achieve the goals of science education regarding the socially constructed nature of scientific knowledge, scientific literacy, higher-order thinking skills, etc., the discursive practices, such as argumentation, must be given a much higher priority than is currently the case (Driver, Newton, & Osborne, 2000). The research studies reviewed so far make point to the lack of opportunity given by teachers for students to discuss alternative views in groups, or to interpret events, experiments, or social issues as a class (Driver, Newton, & Osborne, 2000). It is clear that efforts at the level of science curriculum are not enough to accomplish the systemic application of argumentation in science classrooms (Jiménez-Aleixandre & Erduran, 2008).

An example to this case is a study by Yalcinoglu (2007), where she investigated high school biology teachers' epistemological criteria and their attention to reasoning and argumentation within their instructional practices. Teachers were asked to provide an argument about the validity of hypothetical conclusions drawn by the students based on two different scenarios related to evolution. The researcher reported that although elements of an argument were visible in the teaching practices, teachers did not explicitly introduce a well-structured argument in their classrooms. As a result, students were not provided opportunities to practice high level of reasoning or improve their argumentation skills.

The main challenge to implementing argumentation in science classrooms is indicated to be the lack of transformation of research and curriculum requirements to educational practice. Jiménez-Aleixandre and Erduran (2008) argue that the gap between educational research, international or national policies and practice in science classrooms is common because of the fact that few research findings are widened to a larger scale of teaching and learning situations in the form of, for example, professional development of teachers.

The professional development of teachers is important because, particularly for the less successful groups, research suggests that improvement in students' ability to engage in argumentation could be achieved through teachers' ability to guide groups in debates (Driver, Newton, & Osborne, 2000). However, using argumentation approach in science instruction is a challenging practice for many science teachers because they must not only go beyond adopting the curriculum or understanding the requirements of educational reforms, but also must know the argumentation strategies and be proficient in carrying-out evidence-based argumentative activities (Zembal-Saul, 2009; Zohar, 2008). On the contrary, the research indicates that teachers are either not familiar to such an approach aligned with constructivist and inquiry-based teaching approaches (Jiménez-Aleixandre, 2008) or not comfortable because such a course of action would require a fundamental shift in the pedagogies that they already use (Driver, Newton, & Osborne, 2000; Simon, Erduran, & Osborne, 2006; Zohar, 2008). In other words, many science teachers argue that handling discourse in science classrooms effectively is challenging and that there are a few general strategies available to manage with discourse, either in small groups or in whole class settings.

Hence, attempts to increase teachers' knowledge, awareness, and competence in dealing with teaching and learning through discourse, and research and development programs that would target specific approaches to enhancing the discursive opportunities in science lessons seem as much crucial as enhancing the argument skills of students (Driver, Newton, & Osborne, 2000). Consistent with this effort, there are a few instructional activities and professional development frameworks for pre- and in-service science teachers that are aiming at introducing scientific argumentation in the science classrooms (Walker & Sampson, 2013; Zohar, 2008). However, scientific argumentation is not emphasized in most undergraduate and graduate science courses, and it has not been a prominent type of discourse among college science educators (Walker & Sampson, 2013).

In the following, there are the results of pre-interviews that I conducted with the participants of this study in order to clarify whether the problem statement that I stated here based on the research is perceived in the same way by the participants.

3.2.5. Participants' initial position regarding argumentation

Participants

Participants were 1 elementary school science teacher, 2 high school science teachers, and 4 graduate students. Their profiles are provided in Table 1 and below in detail. The pseudonyms were given to ensure the privacy of the participants.

In general, participants registered to the course by their own will. That is, the course was selective, so all of the participants chose to take the course because they wanted to learn more about argumentation theory and its integration into science teaching and learning. Therefore, the participants who took the course formed a self-selective group. Thus, one can assume that the group would be above the level of a randomly selected group of science teachers considering their level of curiosity, their motivation for continuous professional development, and their motivation to be up-to-date in educational innovations.

Table 1 Information about the participants

Term	Participant	Teacher/ Ms/ PhD	Years in teaching	Currently employed at	The level (s)he taught
1	Can	MS- Res. Assist.	0	A public university	Elementary
1	Hilal	PhD- Res. Assist.	0	A public university	Elementary
2	Birhan	MS- Science Teacher	4	A private school	Primary & Elementary
2	Mesut	PhD	0	-	Elementary
2	Asya	PhD- Chemistry Teacher	11	A private school	High
2	Seher	PhD- Chemistry Teacher	6	A private course	High
2	Mahmut	MS- Res. Assist.	0	A public university	Elementary

Participants were contacted one by one prior to the beginning of the course, and asked for their consent to participate in this study. Of the 7 participants, 3 pursue their Master of Science degree and 4 pursue PhD degree in science or in chemistry education. Three participants were research assistants at the department of elementary education, one taught at a private elementary school, one taught at a private high school, one taught at a private course centre, and one was a graduate student, who did not have a teaching experience prior to the study. At the beginning of the study, 3 teachers had been teaching for 4 to 11 years (*M*= 7 years, SD=3.6 years). Only one participant, Mesut had prior knowledge about argumentation since he studied argumentation in his master's thesis.

1st participant- Can. Can was a graduate student, who pursues a Master Degree at the department of elementary science and mathematics education, and he was a research assistant at the same department in a public university. He had his Bachelor of Science degree at the department of elementary science education, in a public university, where the teaching language is Turkish. After he was graduated, he was employed as a research assistant and he was transferred to the university, where the teaching language is English. He stated that his master thesis was going to be about environmental education, specifically sustainability education.

He subscribed to the course in the first semester. At the time of the study, he had been a research assistant for a month, so he stated that he had no experience in teaching either as a science teacher in an elementary school or as a teaching assistant at the university. He said that he took courses related to teaching practice and school experience, but he emphasized that he just observed the classes but had no teaching experience even during his internship:

> "Question: Do you have any teaching experience?
>
> Can: No, I don't. When I was studying at X University, there were courses such as practice in teaching I and II, but I had never taught in these courses as a science teacher. I was an observer. There were only my observations in elementary schools and short activities that I had in my undergraduate class. I had no other classroom management and teaching experience.
>
> Question: What about teaching at university as a teaching or research assistant?
>
> Can: I guess you talk about the micro-teaching experiences. In the courses, such as methods of teaching science-I and planning for teaching in science and technology, I taught one lesson chosen from science and technology curricula to my classmates. These are my only experiences. If you ask my experience during assistantship, I don't have any, yet."

2nd participant- Hilal. Hilal was a graduate student, who pursues a PhD Degree at the department of elementary education, and she was a research assistant at the same department in a public university. She had her Bachelor of Science degree at the department of elementary science education, in a public university, where the teaching language is English.

She subscribed to the course in the first semester. At the time of the study, she had been a research assistant for a semester, so she stated that she had no science teaching experience:

> "Question: Do you have any teaching experience?
>
> Hilal: I haven't had any experience in science teaching in a real classroom environment. I was a research assistant in the course of teaching practice, and community service last year. Also, I was a research assistant in the course of statistics but I did not teach science in that course, but I assisted statistics labs. I did not do science teaching, but I did teaching."

3rd participant- Birhan. Birhan was one of the elementary science teachers who attended the second term argumentation classes. She has been teaching science to upper primary (5th grades) and elementary grades (6th to 8th grades) for 4 years in a private school. She is also enrolled in elementary science and mathematics education graduate program. She graduated from the elementary science education undergraduate program from a public university, where the teaching language is English. She is responsible for teaching science almost 30 hours a week.

Birhan told that she teaches in Turkish but can use activities in English as well because students have a good understanding and speaking in English. Therefore, she was comfortable in using words in English. She also expressed her attitude towards science teaching in such a way that she enjoyed the "methods in science teaching" courses in her undergraduate education because by means of these courses she had had a feeling such that she would have been a teacher. Birhan was very happy about her school in terms of the self-development opportunities. She told that she has been developing her teaching endlessly and the continuous supervision by the science department of the school plays a great role in her development.

4th participant-Mesut. Mesut was one of the PhD students at the department of elementary education. He participated in the second term argumentation classes. He graduated from elementary science education department at a public university. He had his MS degree in the elementary science and mathematics education department at the same university. He had no experience in teaching science in schools except his internships during his undergraduate program. During these internships, he had chance to observe a science teacher in a school setting and to teach science to elementary students twice. He studied argumentation in his MS thesis. Therefore, he already had a well-established theoretical understanding of argumentation in science teaching and learning before the course.

Mesut first mentioned about his MS thesis, where he investigated whether there is a correlation between science content knowledge and the quality of argumentation. He shared the results of his MS thesis with the researcher.

5th participant- Asya. Asya was one of the science teachers who attended the second term argumentation classes. She has been teaching chemistry to high school students (9th to 12th grade) for 11 years in a private school, where the teaching language is English. She was teaching chemistry for the International Baccalaureate (IB) Program, which is a comprehensive and rigorous two-year curriculum, leading to examination for students, and culminating in the award of a diploma. The IB Preparation Program is offered to grades 9 and 10, and the IB Diploma Program is offered to grades 11 and 12. Being the chemistry teacher in these classes, she had to teach advanced chemistry to high school students.

6th participant- Seher. Seher was one of the science teachers who attended the second term argumentation classes. She has been teaching chemistry to high school students (9th to 12th grade) for 6 years in a private exam preparation centre, where the teaching language is Turkish. The centre is aimed to prepare students for university entrance exams. These centres are different than the regular high schools in terms of their facilities and teaching programs. The centres do not have laboratories, and their teaching programs are supportive, i.e. their main purpose is not to teach a new subject, but to provide additional support for practising knowledge and solving related exam questions.

7th participant- Mahmut. Mahmut was a graduate student, who pursues a Master Degree at the department of elementary science and mathematics education, and he was a research assistant at the same department in a public university. He had his Bachelor of Science degree at the department of elementary science education, in a public university.

His teaching experience was limited to three months in a private exam preparation centre:

> "Question: Do you have any teaching experience?
>
> Mahmut: I worked in a private exam preparation centre for three months when I was in third grade in my undergraduate years. I preferred to start graduate education later. I have been to a class about argumentation in another course, which motivated me to take this course. That is all my experience so far."

Pre-interviews to explore participants' understanding of the problem

Pre-interviews (Appendix A. Pre-interview questions, p.318) were conducted in order to clarify whether the problem statement, which I derived from the literature review as the lack of argumentation opportunities in science classrooms and teachers' lack of expertise in argumentation, briefly, is perceived in the same way by the participants. Pre-interviews provided me with the participants' viewpoint in terms of the integration of argumentation or any discourse- since some of them were not familiar to argumentation before attending to the course- and their perceptions of any problems accompanying with the implementation of discourse in their classrooms.

Structure of the pre-interviews

Pre-interviews with the participants were hold one-by-one prior to the course. Each participant was first asked about their background related to their career as a science teacher. This information was reported in participants' profiles (see Participants, p.110).

In the pre-interviews, the participants were also asked questions related to their knowledge and implementation of argumentation or any discourse in their previous teaching experiences. Discourse, here, was the term used to cover all kinds of conversation, which describes a formal way of thinking that can be expressed through language. The term discourse was used in the pre-interview because I predicted that all of the participants might not be familiar with the term argumentation in specific. This terminology was a limitation in the pre-interview because the terms discussion, discourse and argumentation do not refer to the same concepts, and the participants may not assign the same meaning that I do for these terms. For this reason, I asked the participants for clarification of the terms in the pre-interview. However, in the post-interview, the term argumentation was used.

One of the questions in the pre-interview required the participants to construct argument(s) regarding the particle structure of matter. In this question, the participants were provided four alternative evidence statements. The participants were asked to support the given claim with appropriate evidence statement(s) and to argue why the other statements were not appropriate. By means of this question, I aimed to evaluate the participants' acquaintance with an argument. In other words, I expected to see whether participants would evaluate the evidence statements to construct an argument and would consider the value of alternative statements in terms of argument quality, even though they do not use the terms argument or argumentation before.

The last part of the interview was designed in order to see whether participants were able to recognize and evaluate students' argumentation in scientific contexts. For this purpose, I structured a question that involves two students' answers in a real argument-driven inquiry class, which were taken from the presentation by Sampson (2009) in Turkey. My expectation regarding this question was that the participants, who were unfamiliar with argumentation practices, would make naïve evaluations of students' arguments. In other words, they would not consider, for example, the quality of the arguments in terms of the adequacy of the evidence presented and the appropriateness of the justification. Rather, I expected that the participants would only focus on the scientific correctness of the arguments. This result would give idea about the participants' naïve conceptions of an argument and the quality of argumentation.

Analysis of the pre-interviews

The first part of the pre-interviews were analysed through IPA method (see Interpretative phenomenological analysis of interviews, p.42). My aim was to understand in detail how the participants made sense of their prior experiences regarding argumentation and/or discourse based classes in relation to their social world. I explored the meanings that the participants assign to their experiences. Therefore, first, I focused on participants' description of their experiences regarding argumentation and/or discourse based classes (phenomenology perspective) and second, I made sense of these experiences in relation to a wider social, cultural, and theoretical contexts (interpretative perspective).

The second part of the pre-interviews, which required the participants to construct arguments related with the particle structure of matter, was analysed by using Toulmin's Argumentation Pattern (TAP) analytical framework by Erduran, Simon, and Osborne (2004). My aim was to evaluate the quality level of the participants' arguments before taking the course in order to track changes in their understanding of high-quality arguments throughout the course. In TAP analytical framework, arguments are categorized in 5 levels according to their quality. The quality is evaluated based on the inclusion of argument components proposed by Toulmin (1958). For example, low level argumentation consists of arguments that are a simple claim versus a counter-claim or a claim versus a claim, while high level argumentation displays an extended argument with more than one rebuttal (Erduran, Simon, & Osborne, 2004).

The last part of the pre-interviews, which required the participants to evaluate students' arguments, was analysed by classical content analysis through a qualitative procedure. Specifically, I followed an empirically and methodologically controlled analysis of the transcripts of the participants' evaluation of students' arguments within the context of the pre-interview, and followed content analytical rules to display the basic points that the participants focus while evaluating students' arguments (Mayring, 2000).

Results

Part-I: Argumentation/ discourse/ discussion in a science classroom. In the first part of the pre-interviews, I asked the participants about their views regarding the initiation and implementation of argumentation or any discourse in a science classroom. In the following, their responses were presented:

Case 1-Can. In the pre-interview, which was 47.42 minutes long, Can believed that students should have a readiness in any content for argumentation. He added that planning an argumentation-based lesson is a difficult task at elementary level. He justified his position by implying that argumentation requires higher-order thinking skills:

> "Question: Well, what about discussion, or I'd rather would like to say, discourse?
>
> Can: Some activities, such as brainstorming, which do not require higher-order thinking, have already been practiced in science classrooms. Similarly, if there is more than one response to a teacher's question, discussion starts immediately. However, I think that argumentation practice would be more difficult."

After receiving this answer, I thought that Can had some prejudgments in his mind about bringing argumentation practices to elementary classrooms, such as it would be too difficult for elementary school children. Therefore, I assumed that the knowledgebase Can had about argumentation might block the conversation between us, so I continued to the interview by using the term discussion.

According to Can, initiating a discussion was not difficult and a number of strategies would be helpful for this purpose. For example, he suggested that brain-storming, challenging questions of the teacher or different answers to these questions can be examples of discussion initiation techniques. Other examples were competitions between groups of students, and group work. He also gave examples to teacher-directed questions:

> "Can: A case can be presented and students can be questioned about the case such that 'what could be next' 'what could be the result of this case', and-if the case is ill-structured- 'how the case can be solved'. Visuals such as photographs can be useful to ask 'what do you think about this one'. There can be simple animations such as a velocity-time-displacement graph of a car to ask 'how would you draw velocity-time graph or displacement-time graph of the car', or a molecule structure of a matter to ask 'what do you expect to observe about the molecules when the heat is given to the matter'. Then you can play the move and let them compare their answers. We can ask first their predictions and then show them the reality."

The approach Can suggested was more teacher-centred in terms of the person who asks questions. Moreover, the suggested teacher-directed questions do not require students' to make justifications for their choices or claims.

Case 2-Hilal. In the pre-interview, which was 31.49 minutes long, similar to Can, Hilal was thinking that the students should be prepared for an effective and productive discourse:

> "For a better discussion, students might read the textbook- if it is a good one-beforehand or search Google- if the students are competent enough to decide the reliability of the source."

Hilal was a graduate student and she had no experience in science teaching in elementary schools. Therefore, it is likely that her answers were more influenced by theories in science education in terms of her emphasis on the quality of the textbook and the students' ability to decide the reliability of a resource.

In addition to students' readiness, Hilal was thinking that the teacher's role is important:

> "I think that teacher always should have questions to facilitate discussion. In order to promote interaction among students, I may encourage them to ask questions to each other in a group work, to involve together in an activity, to work on a mechanism all together or in pairs."

The role of the teacher, as opposed to Can's suggestion, was more student-centred in Hilal's answer. Hilal was pointing to teacher as a facilitator rather than being the one who asks questions. She also suggested a number of techniques to initiate discourse in a science classroom:

> "For example, a case- concrete and possible- related to a real life makes initiation of a discussion easier for teacher. … techniques similar to questioning are effective ways to initiate a discussion. Textbook is a good idea to use. In addition, based on the topic of discussion such as theory or laws, related activities can be found. I mean that students may experience the buoyancy force in an experiment. I think that teachers make use of the history of science as well. They may provide students with information about scientists or history of science to serve as a scientific background."

To summarise, Hilal suggested presenting cases, questioning, activities or experiments, and the use of history and philosophy of science to initiate discourse.

Case 3-Birhan. In the pre-interview, which was 37.23 minutes long, about argumentation, Birhan said that she had no idea about argumentation before the classes. However, she shared her views about discourse in general. She was thinking that during discourse teacher should act like a guide rather than a transmitter of ideas, and students should have a background on the topic of discussion:

> "As much as I know about the discussion, I think that teacher should direct the students but not give too much idea. I think that students should be prepared for the topic of discussion. Students should be in heterogeneous groups but two or more groups should be homogeneous."

Her views about discussion shaped the context such that students study within heterogeneous groups and groups are homogeneous between themselves. All above this, she believed that teacher should have good classroom management skills. Although she said she did not name it as argumentation, she was thinking that the discourse that already goes on in her science classrooms might be considered as similar to argumentation in terms of the initiation-response-evaluation (IRE) cycles that take place during discussions:

> "Although we do not call our lesson as discussion, considering the frequency of question-answer and evaluation etc., I think in some way within argumentation."

However, she was cautious about the time it takes for a deep understanding of a subject. Therefore, she was thinking that to achieve such deep understanding, groups should have good listening skills. About the content of discussions, she was thinking that students should know the concepts, and the concepts should be linked to students' lives. She was considering the science lessons as sessions of debate where the aim is not to agree on a view but rather to explicate a concept for better understanding:

> "I think students should know the concepts prior to the discussion. They should have background knowledge. Moreover, we can make them inquire about the things in their daily life, what they think. Considering the science course as a debate, I think the discussion is not for convincing others but for deep investigation of a topic. In any case, I believe that the students should be ready. Otherwise, it makes no sense even if we call it discussion."

She emphasized the prior knowledge that the students should have several times. In terms of the strategies to initiate and flourish discussions in her science classrooms, she said she makes links to students' lives. However, more important than all, she was recognizing the importance of developing students' thinking skills in science. Therefore, when teaching thinking skills such as identifying and controlling variables, conducting a science project, etc., she said she relies on the exemplar cases which create dissatisfaction in students' minds in order to foster students' thinking. By the end of this process, she indicated that although it takes time, students construct an understanding by themselves through the inquiry of the cases. She was thinking that the students should talk informatively either based on experiment or observations. Therefore, I concluded that Birhan is student-centred but emphasize the active role the teacher takes.

Case 4-Mesut. In the pre-interview, which lasted 40.02 minutes, about the effectiveness of argumentation, Mesut said that his response to the question would be different for national and international contexts. The international literature about argumentation in science teaching and learning gave him the idea that argumentation is an effective mean in science lessons in order to contribute to an understanding of science and its nature. Considering the national context, he was hesitate to say that argumentation would be effective in Turkey because he was thinking that as in the establishment of constructivist approach to science education, argumentation would need time and intensive effort from the perspective of teacher to be adapted into the science classrooms:

> "…when we look at the Turkish context, we see that school culture, classroom culture or personal culture is not appropriate for argumentation. In other words, since argumentation requires directly or indirectly what constructivism requires, argumentation is not something that can be implemented in Turkish context because, for example, we can think argumentation as a concept which is not included in the job description of teachers. Because as much as for constructivism gives most of the tasks to teachers and we need formal things, for argumentation, I mean discussion, we will need so much time. However, our usual progress is more conventional. I mean, it take place in a traditional way from teacher to the student, that is we perceive this as an argumentation as well. There is rhetoric here. Our school culture, therefore, is not appropriate for argumentation. Because, although our curriculum is prepared as constructivist, I assume that when we scale curriculum from constructivism at one end and traditional at the other, our curriculum will fall to the traditional side of the scale. That is what is seen based on the observations or evaluation of the curriculum."

He believed that teachers need to shift their paradigms about science teaching and learning for argumentation to enter into science classrooms. Moreover, as he emphasized, it is not only the pedagogical knowledge related to argumentation but also the epistemology of argumentation that should be given to the teachers. He furthered his ideas to include students in the process such that students should have the skills not only in constructing high quality arguments but also in inspecting the others' arguments in terms of quality and content. Furthermore, he was insisting that the epistemology of science and argumentation should be in science classrooms, which could only be achieved by the shift of paradigms not only for teachers but also for school because argumentation has specific requirements in terms of school and classroom culture:

> “We intentionally or unintentionally relate argumentation with cognitive constructivism or social constructivism. Actually, argumentation needs indirectly what all these need. How can I give an example: first of all, students need time. For what? Because after teacher come up with a claim such as ‘different weights fall down to the ground at the same time if they are left from the same height’, for the students to discuss this, they first need to think, need to consider their backgrounds, and extend the time for discussion, and this requires time. I guess we have limited time for argumentation in formal learning contexts. I don’t believe that argumentation, argumentative thinking or reasoning in its real meaning can take place in such a limited time interval. The components might be first increasing the time, or there should be so effective materials should be developed that they shorten the time but involve students in an argumentation process. As I said, we should impaste all included in this process constructively. What is in this process? School administrator, I mean what is in school context should be explained here. Therefore, all components of school context should be in this. I mean, in terms of pedagogical content knowledge, teachers; a curriculum in which argumentative roles are included; even school administrators can think argumentatively, which is possible; parents; all people in this culture; I mean that the culture should experience a paradigm change that will have an impact on all its components. How could it be possible? I don’t know but I am sure it can be done or I think there is a credibility or rationality.”

In summary, Mesut explained the requirements for inclusion of argumentation in science classrooms based on the associations made between argumentation and cognitive as well as social theories of learning such that all requirements for these learning theories are somehow also ruling argumentation. He gave examples of such requirements that (1) the need for enough time for students to construct and evaluate arguments, (2) teaching and learning materials effective for argumentation, (3) pedagogical knowledge of argumentation for teachers, (4) organization of school culture, where the decisions are made as a result of argumentative processes, (5) curriculum emphasizing the argumentation skills and processes, and even (6) parents who value argumentation.

Mesut was considering argumentation in a broader sense and resisting categorizing it as a teaching or learning tool or method. His expression was:

> “I don’t want to say we teach through argumentation or it is a teaching tool or students learn through argumentation. It can be a lifestyle, it can be a style. It is like that you can live argumentative.”

About the effectiveness of argumentation in a science lesson, he was considering that the quality of argumentation is important and the lesson should be planned to increase this quality. He was evaluating the quality of argumentation based on a few criteria:

> “First of all, high quality- for me, of course it is an idea from literature but it is rational for me, I adopt it, I believe in this perspective: while students give data for knowledge claim, and coordinate the relation between data and knowledge claim, whether they can present elaborated justifications. This is a level. This is a criterion for me an initial one. First of all, students should have this. …Then, students have to look for the perspectives that they can falsify themselves as well as others’ claims, and argumentation should be implemented so that students feel that they are urged to learning. … So there are two criteria: one is related to justifications, and the other is an evaluation criterion which refers to rebuttals.”

To summarize, the criteria for evaluation of argumentation were (1)the elaboration of justifications in an argument through higher order thinking, (2) students’ urgency to consider alternative viewpoints, counter arguments and rebuttals as they are in Toulmin’s argument structure, and (3) to what extent the argumentation leads to the necessity of further learning. Before his argumentation on a given issue, Mesut also expressed his attitude towards argumentation in a few words: He was thinking that argumentation is difficult especially in socio-scientific issues, and the quality of argumentation would be better through social interaction compared to an individual argumentation.

Case 6-Seher. The pre-interview with Seher was lasted 17.03 minutes long. In the pre-interview, Seher first focused on the context- and content--related requirements for discourse:

> “The classroom should be arranged so that all students can see each other. If there are students at the back of the classroom, they may not participate. Teacher should sit to give a message that I am not the authority of the classroom but you are in charge of your own learning. The topic should be open to discussion. The answer should not be so clear in order to have a discussion. Discussion, I think, should not be ethical or religious because it may end up bad.”

The main issue Seher mentioned for the persistence in discourse on a topic was the time to be devoted for discourse:

> “The duration of discussion is also important in our education system. Besides, there is the question whether longer is better for learning. I believe that the longer the discussion grows the boring it becomes. The discussion loses its point.”

Seher was working at an exam preparation centre, which was different than a regular science classroom in terms of facilities as well as teaching approach. This difference was also clear in Seher's response to the question about techniques because she usually did not intend to initiate a discussion:

> "Question: Well, how do you initiate discourse/ discussion in your own classroom? Which techniques/ strategies do you use? How discussion pops up in your classroom?
>
> Seher: I cannot say that I am using this or that technique since I don't initiate a discussion on purpose. However, I try to catch the misconceptions or the common mistakes that students always fall into in order to initiate a discussion. Sometimes, I try to guide them. …In this case, I did not have an intention to start a discussion but the student did. S/he came up with many suggestions such as keeping the temperature at a certain level etc., which leads to a discussion. Unfortunately, the class was not so excited about the case so the discussion ended up between me and her/him rather than class. This is a struggle."

In addition, although she did not know the concept argumentation and did not initiate argumentation on purpose, Seher had a positive attitude to the alternative viewpoints that might be forwarded by the students:

> "I look for evidence, a ground to build an idea on it, then I think that yes; it is a key point to discuss. Additionally, there can be opposite viewpoints. S/he may say something just the opposite. This may also initiate a discussion because when everybody agrees, there is nothing to discuss. However, if there is an opposite idea, you can play on it and say yes, let's discuss about it."

I emphasize this attitude because I think that a teacher's acceptance of the possibility of variety of answers to a scientific case is an important epistemic belief related to science and argumentation in science. Similarly, among the participants, who did not have a prior knowledge about argumentation, Seher was the only one, who explicitly mentioned about the importance of evidence in science and so justification. Her viewpoint regarding the role of evidence in science is critical for argumentation in science.

Case 7-Mahmut. The pre-interview with Mahmut was lasted 37.05 minutes long. In the pre-interview, Mahmut focused on the context-related requirements for discourse:

> "First of all, the norms of the society should be taken into account. We should show respect to each other to communicate. I think that there should be a small

group of people for an effective argumentation. …Context is important as well. … As I said, respect is a must for a good discussion."

Moreover, alike other participants, Mahmut emphasized the content to be of interest to students and the students' background for their readiness for a discourse. About the role of teacher, Mahmut draw a line between being an authority and being an informative guide:

"Also, the moderator should be well-trained but this may lead students to keep their silence. Sometimes, teacher is authority and likes the class to be quiet; in that case students do not talk at all."

Mahmut did not give examples to strategies and techniques probably because he was not experienced in science teaching. However, he put emphasis on the empirical, specifically experimental data, for the persistence in discourse on a science topic:

"I think that we should take the experimental data into account. If we are in a scientific search, we should think about the experimental data. Demonstrations are another option because in the absence of data, we cannot do more than reasoning in a discussion. After a while, the discussion does not go further unless there is data. Furthermore, I cannot reach a conclusion such as the highest density of water is at 40C degree just through discussion. Despite the nature of science is open to discussion, tentative and subjective, experiments are valuable to go further. I think that experiments are like a gateway to empiricism. They don't need to be at the beginning but at any point of the discussion. I don't say that we must do an experiment at the beginning for a discussion. We might discuss the possibilities, test them by experiments, and conclude with another discussion of the results. This might be another way of discussion in the light of empirical data."

Mahmut, already, explicitly stated that the perspective he had was empiricist. Therefore, he put emphasis on empirical data and this emphasis can be evaluated as the importance he attributed to evidence in discourse, especially while studying on a science topic.

In overall, the participants, except Mesut, did not have a theoretical background related to argumentation before the course. Therefore, the responses in the pre-interview were more related to any discourse that can take place in a science classroom. In summary, the participants' responses were grouped under three categories (Table 2): requirements, constraints and techniques.

Requirements are appropriate conditions, roles and content for an effective discourse to take place. For example, context-related requirements that the participants suggested

Table 2 The participants' views related to Argumentation/ Discourse/ Discussion

	Context-related	Content-related	Student-related	Teacher related
Requirements	small group	interesting	background	well-trained
	size of the class	experimental data	competent	guide
	arrangement	open to discussion	readiness	look for evidence
	school culture	not ethical or religious	respect	facilitate
	constructivist	related to real life	excitement about the case	promote interaction
			skills to test their claims/ arguments	classroom management
				PCK for argumentation
				epistemology of argumentation
				knowledge about the quality of arg
Constraints	time	planning		teacher authority
		effective materials		
Techniques	questioning	case studies	daily life examples	activities
	brain-storming	misconceptions	analogy	history of science
	competitions	students' suggestions	experiment	problem situation
	group work	opposite viewpoints	demonstration	inquiry

were arrangement of the classroom environment to allow small groups work collaboratively and see each other during discussions; encouraging all components of the school, such as administrators, teachers, students, etc. to adopt argumentative thinking in school culture; and dissemination of constructivist approaches to teaching and learning. Content-related requirements, which participants emphasized were presenting students interesting and open-ended cases, which relate to their life without ethical or religious concerns; and providing experimental data for their justifications. The participants emphasized the requirements, which were student-related as students' having background and readiness as well as interest in topic of discussion. In addition, they suggested students to be respectful to others' ideas; and to be competitive as well as skilful in discourse in terms of evaluating these ideas. Moreover, the participants indicated that teachers were required to be well-trained in discourse, classroom management, and argumentation so that they could be a guide and a facilitator; to promote discourse when appropriate by considering the importance of evidence; and to have an epistemic understanding related to science and argumentation.

The constraints against the implementation of any discourse in science classrooms, from the perspective of the participants, were teachers' announcing themselves as being the judge or the authority of the discourse; the duration of the lessons; and the lack of appropriate planning and materials for a productive discourse.

Despite the significant number of requirements and constraints, the participants suggested many teaching strategies or techniques for promoting discourse in science classrooms. These strategies and/ or techniques were listed in Table 2. These strategies and/ or techniques were required students to be active in learning process in general. However, only a few participants emphasized the possibility of the alternative viewpoints during discourse, and the importance of evidence and justification in the construction of the scientific knowledge.

<u>Part-II: Construction of an argument.</u> In the second part of the pre-interviews, I asked the participants to argue about the particle structure of matter and I presented them four evidence statements that they could use in support of their argument. The arguments of the participants Can and Hilal about the particle structure of matter had three components (e.g. claim (C) - data (D) - warrant (W)). For example; the argument Can constructed was that:

> "D makes more sense to me **(C)** because students may understand easily when they observe a paper can be cut into very small pieces **(D)** and they are told that the smallest piece would be its atom **(W)**. I think D makes more sense…It is both

> observable and clear. If I had to choose, I could choose D because it refers to the particle structure of matter and is clear enough to teach the claim to the students."

The first argument Can constructed did not involve any rebuttal, but when he was asked why he did not choose another one, he provided a counter-claim (CC) without any justification:

> "A says that the air inside a syringe can be compressed, which supports the claim that matter has a particle structure but, I think, even stronger it supports the claim that there is space between particles **(CC)**."

Similarly, the argument Hilal constructed had the same three components, and when she was asked to, she integrated a weak rebuttal:

> "Ok, I'd like to say A **(C)** because A talks about the compression of a gas. The matter is a gas. When compressed, the distance between particles is decreased and gas compressed to a compact structure, so we can infer that matter is composed of something else **(D)**. I may better explain myself by an example of a liquid. A liquid can be compressed; there is a small decrease in its volume. This decrease in volume indicates that there are other things composing the liquid and they approach to each other. We can infer that these other things are particles **(W)**. …I would tell someone, who disagrees with me, that the decrease in the volume of a gas in a syringe could not be possible otherwise. That someone, who disagrees with me, might think that something inside the matter can move but in all cases the decrease in volume is only possible by means of the movement of the particles **(R)**"

The arguments constructed by Birhan, Mesut, Seher and Mahmut were different in structure because they evaluated all choices when constructing their final arguments. Thus, their arguments involved rebuttals (R)-weak or strong- and therefore, their arguments were higher in quality based on the TAP analytical framework (Erduran, Simon, & Osborne, 2004). For example, in the argument Birhan constructed, she evaluated each statement one by one and integrated rebuttals regarding each one:

> "A is about gases. It cannot be generalized **(R)**. (Reading) all crystal composing a solid matter has similar shape. Because they cannot see this, it is a model after all; they cannot be sure about this **(R)**. … (Reading) paper can be divided into very small pieces. In D, it is like it is only be as small as we cut but no more **(R)**. … I think C can be **(C)** … Compressing the air in a syringe is related to the spaces between gases **(W)**. That is correct. That is an explanation but in this case a child

may say solids cannot be compressed so is it means that there are no spaces between **(R)**? So (s) he may reach to a false generalization. (Reading) all crystal composing a solid matter has a similar shape….There can be examples not like this **(R)**, I don't know. That is why it doesn't make sense to me. … (Repeating) water in a small pond disappears in a while. The reason for me choosing this one might be that if the matter was a whole in structure it would evaporate all at once **(D)**. That is how a child might think. However, because it is not like that and (s) he can see that in his/her daily life **(D)**, (s) he might better think that matter is composed of particles by this way. …All water doesn't disappear at once, it disappears in dribs and drabs **(D)**. Therefore, it is something like "it composes of particles" and there we have evidence."

The argument constructed by Seher was very similar to the argument by Birhan in the structure and the components:

> "I think it is c: water disappears in a while **(C)**. This is evaporation. …Since it is a slow process, which would be at once unless there are particles, and water disappears in small drops that we cannot see, we can infer that there are particles invisible to eye **(D)**. We can cut a paper into pieces but at some point, we can't make it any smaller **(R)**. In this case, students may think that this is the smallest particle, there is nothing any smaller. They may not imagine a smaller piece. Air compression is more related to the space between particles rather than the particle itself **(R)**. Gas molecules fill the volume they are in and gas can be compressed **(W)**. I don't like the statement about the similarity of crystals in a solid well, they are the same but they might not be. There are some alloys that have irregular structure **(R)**."

When constructing their arguments, Can, Birhan and Seher thought from the perspective of a teacher. They first suggested the answer to be clear to students, so their choice was based on the existence of empirical evidence, which is observable.

The argument constructed by Mahmut was brief compared to others' arguments, but still had rebuttals in addition to warrants and backings;

> "I say b, which states that all crystals in a solid are in the same shape **(C)**. …Pure substances have the same kind of atoms, and the atoms of the same substance, such as ferric, are all in the same size and shape **(B)**. I think that particle structure is the composition of the smallest particles **(W)**, so b makes sense. Since we talk about a solid matter, it might be a more concrete example. I mean that water evaporates, but I cannot observe that as a particle **(R)**. Similarly, gas can be

compressed but it gains volume when released or it is not clear to what extent you can cut a paper into pieces **(R)**."

Mesut followed the same strategy while constructing his final claim. Alternatively, Mesut agreed that all statements support the given claim more or less. Therefore, regarding some of the statements, Mesut did not integrated rebuttals. Rather, he supported his main argument by means of these evidentiary statements as well:

> "The matter is made up of particles and air is a matter in the form of a gas. Gases have space between particles compared to the other forms of matter **(W)**. I know that these particles can be closer or away from each other in certain conditions **(B)**. Therefore, if we don't change the temperature or the amount of air in the syringe, by decreasing the volume most probably we make the particles come closer to each other **(W)**. ...About the last statement, … I think this statement could be only considered as a start to form a scientific model because although particle nature of matter implies that matter can be divided into particles, it is not as simple as dividing a paper into smaller papers, and because there is an so called interaction between those atoms which keeps them together chemically or physically, and even biologically when we consider organisms…, there won't be any interaction between paper pieces regardless how small I divide them **(R)**. Let's look at the second one. …We cannot observe deep inside of matter because of the technology we have but we know elements are made up of the same atoms **(B)**. …, we can say that elements are composed of same atoms and these atoms are the particles of matter in real **(B)**. (Reading) water in a small pond disappears in a while. …We can do something like that we can collect the evaporated water in a container before it disappears and then condense it and have the initial form of matter back **(D)**. Based on our prior knowledge, …by stating that the relative positions of particles change when the matter changes its form **(W)**, we can predict the particle nature of matter."

In overall, although most of the participants did not know the concept argumentation and they did not have any idea about argumentation theories, two of them constructed arguments consisting of a claim with either data, warrants, or backings but do not contain any rebuttals (lower quality of arguments according to TAP), and four of them constructed arguments with a clearly identifiable rebuttal (higher quality of arguments according to TAP). This result implies that the participants had a viewpoint regarding the structure of a scientific argument. In other words, all of the participants were aware that a scientific argument had to be supported by evidence, for example, in the form of experimental data or scientific theories. Moreover, most of the participants were also aware that explaining why an alternative position is not supportive is as much important as presenting supportive evidence for the quality of scientific arguments, although they did not use the concept argument in their responses. In sum, the inference I draw considering these data was that the science background of the participants had implications on their understanding of the quality of a scientific argument, and this understanding were reflected on their arguments, although they did not explicitly stated this viewpoint in their responses to part-I questions.

<u>Part-III: Evaluation of students' arguments.</u> In the third part of the pre-interviews, I read two students' written arguments on a case related to the conductivity, and I asked the participants to evaluate students' arguments. The first written argument presented to the teachers was

> "The ice melts faster on block A because block A is a good conductor. Although block A s colder than block B, it is still warmer than the ice. As cold moves into block A, the ice warms up and melts. The ice on block A melts faster because the cold moves from the ice into this block faster."

The second written argument was;

> "The ice melts faster on block A because metal absorbs cold. Block A absorbs cold from the ice which causes the ice to get warmer and melt. This is why block A feels colder than block B; it absorbs and holds more cold energy."

The first and foremost criterion that the participants applied for evaluating students' arguments was students' understanding of a concept in their explanations. For example, when Can was asked to evaluate students' arguments, his evaluation had only this criterion:

> "Here, both students talk about the heat transfer so I couldn't see a difference. Here s/he says that the cold transfers but both students say that cold moves. They don't think cold as heat. …S/he probably understands that heat is a kind of energy so I can say that although both students answer in the same way, his/her understanding of cold as energy takes more credit. …S/he says A is a good conductor. The first student takes credit because of his/her understanding of the heat conductivity. …S/he has an understanding of the scientific concept and utilizes his/her understanding in a case. S/he is able to contextualize the concept."

Similarly, Hilal evaluated students' understanding of a concept in the cases;

> "The transfer has to be from the block to the ice. Therefore, the conductivity plays a role here. That is why I said the first student. Since the block gives heat, the conductivity is a better explanation than absorption. I think about the heat transfer process when evaluating the answers."

The evaluation Birhan made was more detailed but still she only focused on students' conceptual understanding:

> "There are similar things but there is nothing to do with conductivity. This is why I give more credit to this one, because of the accuracy of information. That is, s/he has less misconceptions respectively, and because there is no false information like conductivity in this explanation. That is how I think."

In a similar vein, Seher and Mahmut evaluated students' arguments in terms of students' understanding of related concepts. Contrariwise, the evaluation Mesut made had additional criterion, which was the quality of argumentation. Mesut's approach to students' arguments from Toulmin's argument pattern was expected because of his background with argumentation and specifically, Toulmin's Argument Pattern as an analytical framework:

> "Therefore, although the reasoning in these arguments is wrong, we can still talk about the quality of their arguments. …That is, student justify his/ her claim by indicating that regardless of the heat in the blocks, because of the conductivity of A is higher than B, the ice on A melts faster, although the argument is not acceptable scientifically. …We may call this as quality criteria."

In sum, all participants agreed on that students' understanding of scientific concepts and their use of them in their arguments are the first and foremost criteria to be considered. Mesut was the only one who evaluated students' arguments in terms of their justifications because he had a background related to argumentation research. Except Mesut' quality criterion, none of the participants could provide any additional criteria, such as students' ability to use data, to justify his/her claims, to construct alternative explanations, to record and report their observations meaningfully, etc., which could be related to scientific inquiry and/ or argumentation skills.

Conclusion

I conducted pre-interviews with the participants in order to clarify whether the lack of argumentation opportunities in science classrooms and teachers' lack of expertise in argumentation, are perceived as a problem statement by the participants. In the pre-interviews, I asked the participants' for their viewpoint in terms of the integration of argumentation or any discourse- since some of them were not familiar to argumentation before attending to the course- and their perceptions of any problems accompanying with the implementation of discourse in their classrooms. Additionally, the participants were asked to construct argument(s) regarding the particle structure of matter, and evaluate students' argumentation in a scientific context.

The results of the pre-interview demonstrated that the participants, excluding Mesut, were not informed about the terms argument and argumentation. They were familiar to other spoken and written discourse practices in science classrooms, including small group interaction, brainstorming, questioning, conceptual change, etc. Generally speaking, the participants agreed on the value of discourse opportunities in science classrooms. However, as noted by Newton, Driver and Osborne (1999), they also emphasized that managing discourse in science classrooms is challenging although they suggested a number of strategies for structuring small and whole class discourse. This is an important point to discuss because the models they suggested were authoritative discourse (Mortimer, Scott, & El-Hani, 2012). In dialogic discourse, the aim always is to acknowledge different views. Therefore, teacher is expected to attend to students' viewpoints as well as to inform them with the scientific viewpoint. The authoritative discourse, on the contrary, does not allow the exploration of alternative views. Mortimer, Scott and El-Hani (2012) emphasized that in authoritative discourse the teacher considers only to teaching and learning of the school science point of view. This approach to discourse results with the ignorance of ideas or questions raised by students if they do not contribute to the development of the scientific viewpoint. Only if a student's contribution is perceived by the teacher as being helpful to the explanation of scientific viewpoint, the teacher is likely to care about what the idea is. Authoritative discourse does not mean that only one voice may be heard in science classroom, but in such a discourse there is no exploration of alternative perspectives, or no explicit interchange of ideas, if they are not consistent with the school science view (Mortimer, Scott, & El-Hani, 2012). Therefore, I interpreted the participants' lack of interest to the discussion of alternative perspectives or to the justification of viewpoints as in line with authoritative discourse.

On the other hand, the lack of expertise in argumentation practices did not mean that they were naïve in constructing high quality arguments. In contrast to Zohar's (2008) conclusion that teachers were often incapable of constructing arguments and counterarguments, most of the participants (4 out of 6 participants) had an understanding of well-constructed scientific argument when their arguments on a scientific claim were examined, although they were not acknowledged about argumentation. They were able to justify why an evidence statement was supportive for a given claim, but more importantly, they were able to construct arguments with rebuttal by evaluating alternative statements, though I was not interested in the scientific correctness of their arguments. An alternative explanation for this result might be the structure of the question I directed in the pre-interview. In other words, the structure of the question might lead them to think about the alternative statements and required them to construct justified claims. Nevertheless, this argumentative skill to construct high-level arguments in either way does not ensure that the participants are able to set up argumentative classroom environment in their science classrooms. When their perception of discourse environment was examined, they did not refer to students' or themselves use of evidence or need to justify their claims. Therefore, I inferred that argumentation opportunities in the participants'- who were teachers- science classrooms were rare or none.

In argumentative environments, the teachers are also expected to set criteria for the evaluation of arguments and argument components (Jiménez-Aleixandre, 2008). In the pre-interviews, this role of participants was examined by providing a case of two students' arguments on a scientific issue. The results illustrated that the participants were unable to develop and provide criteria for the construction and evaluation of arguments. Their focus on scientific correctness of the argument or students' use of a scientific concept in an argument shadowed their understanding of a high-quality scientific argument. In other words, although most of the participants constructed arguments with warrants, backings and rebuttals when they were asked to argue about a scientific claim, they did not search for these components in students' arguments.

In sum, based on the results of the pre-interviews with the participants, I inferred that the participants, except Mesut, had lack of understanding in argumentative practices. Moreover as I hypothesized at the beginning of the pre-interviews, they were incapable of structuring argumentation practices in their courses regardless of the level they taught at. Therefore, I investigated a well-considered design solution, which has a theoretical background in science education literature and in practice.

The design solution was a graduate course aimed at teachers' professional development in argumentation in science teaching and learning. However, the professional development of teachers is not a list of steps to follow. There are different approaches to teacher's learning. In the following section, I explicated the theory of teacher's learning that I relied on in this study.

3.2.6. Teachers' Learning

In the review by Ben-Peretz (2011), several tendencies were revealed in the development of the concept of teacher knowledge. The tendency was towards the extension of the concept to involve societal issues as well as a growing focus on the personal aspects of teachers' knowledge. In addition, the role of context plays a crucial role in giving structure to teacher knowledge (Ben-Peretz, 2011). In the following section, I illustrated the conceptualization of teacher learning from different perspectives.

Teacher learning is conceived as a process, which is continuing throughout a teaching career with an interchange between the individual and the collective (Simon & Campbell, 2012; Wallace & Loughran, 2012). In simplest terms, teacher learning is stated as teachers building and supporting knowledge of classroom practice in interaction with various discourse communities, and including principles such as "teacher ownership, focus on practice, coherence, collegiality, active learning and systemic support" (Wallace & Loughran, 2012, p. 303). The teacher learning should incorporate individual teacher's knowledge growth with the professional growth in school and classroom settings, and the social growth including working collaboratively with others in that settings (Simon & Campbell, 2012). However, fundamental to the learning is the internal motivation for teacher that emerges from classroom problems (Wallace, 2003).

There are various models of teacher learning in the literature. To start with, the pragmatic model of teacher learning would suggest that teachers should be given the opportunity to engage in authentic activities supported with critical and reflective practice, to participate in discourse communities, for example, in professional meetings, projects, university courses and conferences; and to develop instructional tools that have potential to be used in that community (Wallace, 2003; Wallace & Loughran, 2012).

Situative theories of science teacher learning can be characterised those in which "knowledge and beliefs, the practices that they influence, and the influences themselves, are inseparable from the situations in which they are embedded" (Peressini, Borko, Romagnano, Knuth, & Willis, 2004, p. 73). The framework proposes that first, learning is situated in particular contexts, so learning situation is a major part of what is learned; and second, teachers' knowledge and beliefs are dependent on the historical, social and political contexts in which learning occurs. Thus, from this perspective, teacher learning "is usefully understood as a process of increasing participation in the practice of teaching, and through this participation, a process of becoming knowledgeable in and about teaching" (Adler, 2000, p. 37). Parallel to this conceptualization of teacher learning, collective-situative researchers study teacher development through such approaches as problem-based learning, case studies, self-study, action research and collaborative learning (Wallace & Loughran, 2012). According to Wallace (2003), teacher learning is situated also in particular grade levels. In other words, teaching to elementary grades and high schoolers requires different level of detail in subject-matter knowledge and pedagogical content knowledge. Therefore, professional development activities for teacher learning would be situated in and around the classroom as well as in other settings based on the goals of the learning (Wallace, 2003).

A distributed perspective suggests that teacher learning does not only involve learning by an individual teacher, but also collaboration with the other members of the classroom, school or wider education community by means of various products and tools used by that community (Wallace, 2003). For the reason that teacher knowledge is, at least in part, socially derived, teachers often required to learn in collaboration. Therefore, teacher professional development must create diverse opportunities for groups of teachers to engage in, and to structure discourse communities, in which new insights into teaching and learning develop, and shared across community members (Wallace, 2003).

The socio-cultural theoretical framework would suggest that learning, including the learning of teachers, is situated in historical, social, cultural contexts (Kelly, 2006; Vygotsky, 1978). Therefore, the experiences of science teachers, that is the process; and the contexts of these experiences, with their challenges, opportunities and aspects of learning, have a major influence on teacher learning (Mansour, El-Deghaidy, Alshamrani, & Aldahmash, 2014).

Research emerged from this perspective views professional development of teachers not only as training of teachers to gain skills but also a process of building a culture (Hewson, 2007; Loughran, 2007). In this view, the impact and implementation of a professional development is suggested to be dynamic and multidimensional process, within which individual and collective dialogues are constituted, and evaluated by their unity with the social, political and economic contexts of practice (Mansour, El-Deghaidy, Alshamrani, & Aldahmash, 2014). The diverse contexts of practice that allow learning for teachers include classrooms, school communities, professional development courses or workshops, as well as brief conversations with colleagues (Borko, 2004). Thus, researchers must study teacher learning within these various contexts and must target the learning of individual teachers as well as the social systems in which they are participants (Borko, 2004).

With regards to the individual teacher learning, research suggests that the voices and perspectives of the individual teachers taking part in professional development (De Geest, 2011), their motivation for change, understanding of the theoretical basis of the curriculum and concomitant teaching approaches, and appreciation of perceived benefits for students (Simon & Campbell, 2012) are critical to understand teacher learning. Indeed, research on individual teacher learning supports that to undertake the challenges brought with new approaches, teachers must really want to change and really be convinced that change will make their and their students' learning more worthwhile (Simon & Campbell, 2012). For example, in attempting to offer a framework, Shulman and Shulman (2004) concluded that, the elements of individual teacher learning involves being "Ready (*possessing vision*), Willing (*having motivation*), Able (both *knowing and being able "to do"*), Reflective (*learning from experience*), and Communal (*acting as a member of a professional community*)" (p.259). Loughran (2007) added that to respond appropriately to this challenge, science teachers need to be prepared to challenge the pedagogies that they already use; be reflective in examining, articulating, and disseminating their learning from experience; and be in continuous search for ways to connect the theory and practice.

Professional development frameworks

In this section, I looked at models for planning professional development. Models take different forms and I discussed some of the features of models that have informed my work with the participants.

Clarke and Hollingsworth (2002) proposed in their interconnected model of teacher professional growth that teacher professional growth is recognized as an inevitable and continuing process of learning through a non-linear structure. In this model, the term "enaction" was chosen to distinguish the translation of a belief or a pedagogical model into action from simply "acting", on the grounds that acting occurs in the domain of practice, and each action represents the enactment of something a teacher knows, believes or has experienced (Clarke & Hollingsworth, 2002).

According to Wallace (2003), effective models of teacher professional development combines a mix of settings, such as classroom, in school and out of school contexts; communities, such as school, colleagues, educational groups; and foci in terms of theory, practice, and tools for learning. The belief underlying this approach to teacher learning is that the development of expertise is domain-specific and learning is situated within specific contexts. Therefore, the teacher development is enacted in ways that derive from and connect to the specific domain that will be taught and students they teach. At the same time, the professional development should allow teachers to evaluate aspects of their learning in one context, and think about the ways to transfer their learning to new contexts or problems they encounter (Darling-Hammond, Hammerness, Rust, & Shulman, 2005).

Hewson (2007) argued that a functional understanding of effective professional learning requires addressing the learning needs of students at the first place because the main goal of facilitating professional development of teachers is to improve students' science learning. Secondly, teachers' should be given voice for reflection on their perspectives and experiences regarding their professional development (Hewson, 2007) because, the efforts of the researchers or professional developers, who are concerned for the development of quality in science teaching and learning, are restricted unless teachers themselves are not the initiators or sustainers of the efforts (Loughran, 2007).

Most contemporary models claim that effective professional learning should be designed so that it is intensive, continuous, and linked to practice; targets the teaching and learning of specific content; is connected to other educational communities; allows the allocation of adequate time and opportunities for teachers to work together and build collaborations; and is continuously supervised and evaluated with ongoing support for teachers to integrate ideas into their classroom practice (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010). Considering these features of effective professional development, a recent model is offered by the Professional Development Design Framework proposed by Loucks-Horsley et al. (2010). The model developed based on the collaborative reflections with professional developers about previously tested programs for mathematics and science teachers. The professional development design and implementation process, which are at the centre of the framework, incorporate commitment to a vision and standard; analyses of student learning and other relevant data; setting goals; planning, selecting and implementing strategies; and evaluation of the results. These actions are influenced by several inputs, such as the knowledge and beliefs of the teacher as well as the professional developer or researcher, diverse contexts, critical issues that may influence the achievement of the goals of professional development, and strategies. The quality of the professional development is evaluated, again using data, to determine the extent to which the entire professional development has changed the context, contributed to the achievement of the goals, compensated the critical issues, and enabled the reduce the differences between the goals of the professional development and the current practices; a process that leads the designer to reflect and revise the professional development (Loucks-Horsley, et. al., 2010).

The model of teacher professional development that I adopted in this study is what Kennedy (2005) represents as the transformative model. According to the model, the theoretical background and research should be presented to teachers and then they should be invited to 'explore' how those ideas might be 'translated' into their classroom practice. Called also as transformational or transformative learning, in this model, teacher empathy with project aims and teacher motivation to engage with ideas through reading and discussion were fundamental for teacher learning. Taylor, Taylor and Luitel (2012)described this process as "examining critically our personal and professional values and beliefs, exploring how our life worlds have been governed (perhaps distorted) by largely invisible socio-cultural norms, appreciate our own complicity in enculturating uncritically our students into similar life worlds, creatively re-conceptualising our own professionalism, and committing to transform science education policy, curricula and/or pedagogical practices within our own institutions" (p.374). In short, the focus is primarily on individual teacher learning, particularly on professional renewal by the help of opportunities to rethink and review knowledge and practices, and through this process gaining skills to become reflective practitioners (Mansour, El-Deghaidy, Alshamrani, & Aldahmash, 2014). Hence, the transformative learning of science teachers, especially via graduate research studies, as Taylor et al. (2012) highlighted, should create an awareness and shift in the basic premises of teachers so that they would be able to develop those skills that they are being called upon to develop in their own students.

Fraser (2007) argues that transformative learning was facilitated when formal, planned learning opportunities were augmented by more informal, incidental learning opportunities that allow greater ownership and control of the processes attending to more facets of the personal and social aspects of learning. Mansour et al. (2014) underlined that empowering teachers in this learning model would challenge the facilitators' views about effective teacher professional development and call for them to work with teachers as research partners, who have voice in their own professional development. Therefore, the facilitator must know and be able to apply the theoretical premises to the work with teachers in addition to opportunities created for teachers to critically evaluate and reflect on their current practices and beliefs about teaching and learning of science and the theoretical base presented in the professional development (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010).

Indeed, it is a hard task for teachers to translate new knowledge into beliefs and changes in practice. It requires teachers to share the values of the new motive and be prepared to take threats (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010), have a desire to change their current practices, have opportunities for action, share their experiences with a community of practice, reflect in order to understand the emerging patterns of change, extend their knowledge and experience; and finally have time to adjust to the changes made through a continuous professional support (Hoban, 2002). Moreover, it takes significant time to begin to use new instructional practices in a competent manner, and teachers should be supported with continuous reflection and feedback in order to feel self-confident to introduce new practices in their classrooms (Clarke & Hollingsworth, 2002; S-TEAM, 2010; Zohar, 2008). Furthermore, Fraser, Kennedy, Reid and McKinney (2007) suggest that opportunities that allow greater ownership and control of the processes are likely to attend to more facets of the personal and social aspects of learning and are therefore more likely to result in transformational professional learning for teachers.

In this study, the transformational learning principles are taken into consideration for the design of the graduate course that was described below.

3.3. Design and Construction

In the context of this study, being familiar with the nature of argumentation is considered to be parallel being acquainted with the subject-matter knowledge because, as it is frequently noted in professional development research, teachers cannot teach something they do not know (Zohar, 2006). Although argumentation is not a specific science topic but rather it is an element of scientific knowledge construction and evaluation, teachers cannot address and practice argumentation in their science classrooms unless they have an understanding of it. Therefore, in the context of the course developed in this study, argumentation is considered as a body of knowledge that teachers need to possess in order to address it effectively in their classrooms. To decide the equivalent subject-matter knowledge in the context of argumentation, the relevant literature is examined in terms of the clarification of the concept of argumentation in teacher education, examination of its components in science teacher learning of argumentation, discussion of its implications for the nature of teacher knowledge in this area and how it may be expressed in teachers' perspective and practice.

3.3.1. Science teacher education on argumentation

Implementing argumentation practices in a traditional classroom requires experiencing a deep, structural change in the basic premises of thought, feelings, and actions related to teaching and learning of science (Zohar, 2008). Teachers are expected to know argumentation strategies, be proficient in carrying-out evidence-based argumentative activities that are common in science, need to be prepared for any fallacies that may occur during the argumentation, and need to have pedagogical knowledge about teaching argumentation (Zohar, 2008). Nonetheless, the challenge is that most science teachers do not have adequate knowledge of the history, philosophy and epistemology of science, very few science teachers have ever taken part in the scientific research and become a member of a community of learners in science, and have not been involved in scientific discourse practices of the scientific community (Duschl & Osborne, 2002). Besides, teachers struggle with the lack of pedagogical experience and the demands of the curriculum to ensure greater involvement of students in the co-construction of knowledge through whole class and group discussion (Newton, Driver, & Osborne, 1999).

Several studies have been undertaken to close this gap experienced by teachers and to introduce them with the appropriate pedagogical knowledge in the context of teaching argumentation. Professional development programs presented teachers theories of argumentation as well as a range of different kinds of argumentation activities and pedagogical strategies. For example, a great deal of research has been devoted to the instructional strategies (Duschl, Ellenbogen, & Erduran, 1999; Kuhn & Reiser, 2006; Osborne, Erduran, & Simon, 2004) or the teaching materials including technology-enhanced learning tools (Bell & Linn, 2000; Clark & Sampson, 2007; Sandoval & Reiser, 2004), professional development workshops for material development and practice of instructional strategies (Simon, Erduran, & Osborne, 2006; Simon & Johnson, 2008; Simon, Richardson, Howell-Richardson, Christodolou, & Osborne, 2010); and the argumentation theory is gradually introduced into teacher education programs as well (Tümay, 2008). The fundamental bases of these programs are the educational requirements that come with integration of argumentation in curriculum, and consequently the need for teachers to reflect the knowledge and skills in the pedagogy and instructional tools that support the learning and teaching process of argumentation in science classrooms.

As regards to teachers' knowledge about argumentation, Zembal-Saul et al. (2002) explored pre-service science teachers' knowledge and use of argumentation strategies. In the study, the arguments generated by pre-service teachers were inadequate in terms of their complexity, and sometimes they did not consider alternative causes. In addition, researchers indicated that pre-service teachers could not determine the evidence within the context of the scientific topic. The research also supported that although there is a need more to be done concerning pre-service teachers' argumentation on scientific topics, it is not practical to expect them to implement argumentation if they do not fully involved or understand (Zohar, 2008).

There were attempts in solution of the problem of inadequate knowledge and skills of pre-service teachers on argumentation. One such study was conducted by establishment of a cognitive apprenticeship learning community at a university (Osana & Seymour, 2004). The aim of the study was to enhance pre-service teachers' argumentation and critical thinking skills in regard to complex educational problems. During the courses, the participant pre-service teachers studied the implications of social and community norms on school structures. The intervention took place over ten class sessions for five-week. The participants were required to engage in both oral and written argumentation activities. The instructor first modelled individual reasoning in argument construction while discussing the questions and problems that had come to his/her mind as she had written an essay. During modelling, the same questions were discussed out loud in the class so that participants would be familiar to the processes such as evaluating and summarizing the information, generating appropriate hypotheses, and judging the evidence available. In the rest of the class sessions, the instructor encouraged participants to apply similar reasoning patterns into their own writing and reasoning about a specific content. During the course of the last four weeks, participants were asked to write two pieces, where they argued about content. In the implementation of the development framework, the instructor offered scaffolding to participants by means of questions, prompts, and encouragement to stay focused. In whole-class discussions, the group focused on the hypotheses that were supported or refuted in each discussion piece. The qualitative data analysis revealed that the intervention of the framework improved the participants' ability to concentrate on judging evidence. In other words, the pre-service teachers were better able to use data while making decisions about problems, and they also demonstrated improvements at distinguishing between the quality and the type of evidence in evaluating the problem. Finally, the researchers concluded that the participants were able to establish correlations in generating evidence against a controversial claim (Osana & Seymour, 2004).

Another example of research in promoting argumentation was conducted by Simon, Erduran, and Osborne (2006), who focused on teaching argumentation in secondary science classrooms. The project, which is called Ideas, Evidence and Argument in Science (IDEAS), aimed to carry school-based research into teaching and learning of argumentation through the design of a professional development programme (Osborne, Erduran, & Simon, 2004).The researchers worked with 12 science teachers over a one-year period to develop materials and strategies to support argumentation in their science lessons. The research reported that to train science teachers to adapt and develop their practice of classroom discourse was possible, because teachers believed that the opportunity for students to reflect, discuss, and argue how evidence did or did not support a theoretical explanation was beneficial to students' engagement with scientific ideas. Consequently, a set of materials were developed to support the professional development of teachers in the area of argumentation in science classrooms. These materials, addressed the knowledge and skills related to argumentation through six steps: 1. An introduction to argument, 2. Managing small group discussions, 3. Teaching argument, 4. Resources for argumentation, 5. Evaluating argument, and 6. Modelling argument (Osborne, 2005).

One specific study employed the IDEAS pack resources for the training of chemistry pre-service teachers (Erduran, Ardac, & Yakmaci-Guzel, 2006). During the training sessions with the IDEAS pack, pre-service teachers were asked to plan and implement at least one lesson argument-based chemistry lesson derived from the IDEAS pack. In addition to the IDEAS resources, the pre-service teachers were further introduced with Toulmin's Argument Pattern (TAP) (1958) in order to identify the structure of arguments throughout the training. After the training sessions, the participants were asked again to plan argumentation-based chemistry lesson derived from the curriculum in use at high schools. In their planning, pre-service teachers were supported with feedback and suggestions from their instructor. The lesson plans planned and implemented by pre-service teachers were evaluated in terms of their ability to structure a task, use group discussions, question for evidence and justifications, model argument, use presentations and peer review, establish the norms of argumentation, and provide feedback to students. The researchers reported findings for two teachers to illustrate the ways that these teachers structure chemistry lessons and support argumentation in secondary science classrooms. Results demonstrated that the pre-service teachers incorporated the pedagogical strategies, to which they were introduced during training, in their lesson plans. Evaluation of the practices supported that the pre-service teachers employed all aspects of teaching strategies using argumentation in their classrooms. The difference was sourced between two teachers from their use of meta-talk and the quality of the feedback, which they provided to the students. Therefore, the researchers concluded that the resources derived from IDEAS pack resulted in attainment of the pedagogical and learning goals of the training (Erduran, Ardac, & Yakmaci-Guzel, 2006).

One of the other courses designed for the training of pre-service teachers investigated pre-service teachers' perceptions of and aptitudes related to argumentation during a science method course (Sadler, 2006). The course was divided into four sessions: (1) explanation of constructivist elements of science teaching such as argumentation, inquiry, critical thinking, nature of science, etc.; (2) collaboration and sharing of ideas to foster the construction of group dynamics; (3) discussion of articles related to argumentation and discourse; and (4) presentation of sample lessons which highlight argumentation and discourse. The author reported that although pre-service teachers agreed that argumentation is central to science, most participants tended to view argumentation as a pedagogical strategy. The author suggested that methods courses could be one possible way of promoting argumentation in science education (Sadler, 2006).

Another study addressing teachers' perceptions of argumentation and the development of their skills in argumentation for an effective science teaching was conducted by Acar (2008). The researcher investigated prospective science teachers' development of argumentation skills and conceptual knowledge in an undergraduate course where argumentation skills were incorporated to an inquiry-based physics course. Improvement was reported in prospective science teachers' argumentation skills regarding balancing, sinking and floating concepts during the course. The improvement in counter-argument and rebuttal evidence scores was reported to be content independent whereas improvement of counter-argument and rebuttal justification scores was content dependent (Acar, 2008).

Tümay and Köseoğlu (2010) investigated the implications of an argumentation-based chemistry teaching course on pre-service chemistry teachers' conceptions of nature of science (NOS). Pre-service chemistry teachers (23) attended to the argumentation-focused chemistry teaching course, which lasted for ten weeks with three hours per week. In the course, the researchers emphasized the role of argumentation in science education, designed activities for small group and whole-class argumentation on chemistry topics (Tümay, 2008), provided opportunities for the pre-service teachers to make evidence-based judgments in regard to specific chemistry topics as well as argumentation in science and science education, and to engage in collaborative work on evaluation of arguments. The argumentation activities prepared by one of the researchers included chemistry topics, such as chemical equilibrium and reaction rate in chemical reactions. A variety of techniques and strategies to promote argumentation were used in the study. Some of them were competing theories, concept cartoons, and predict-observe-explain. Moreover, the role of argumentation in science and NOS were the focus throughout the course, therefore, the researchers employed strategies such as the use of historical science vignettes and role-playing to emphasise these aspects of the training. Following these learning experiences, pre-service teachers engaged in reflective discussions about NOS. the findings of the study revealed remarkable development and changes in pre-service teachers' conceptions of argumentation in science, some of the aspects of nature of science such as tentativeness of scientific knowledge and creativity in science. In overall, the training was reported to have a positive influence on pre-service teachers' views about the role of argumentation in science and science education. The researchers linked the success of the training with the opportunities provided for pre-service teachers. The pre-service teachers had experiences on argumentation in chemistry topics, and their critical thinking was enhanced throughout these experiences (Tümay & Köseoğlu, 2010).

In addition to studies examining the development of pre-service teachers' argumentation, there are also studies with in-service teachers. For example, a recent study by Yıldırır and Nakiboğlu (2013) addressed chemistry teachers and prospective chemistry teachers' views on preparation and implementation of argumentation- based chemistry lessons. Participants of this study were 4 experienced and 4 prospective chemistry teachers who implemented argumentation-based chemistry lessons in high school chemistry classes.

The data were collected by a semi-structured interview form and analysed by using the descriptive analysis method. Additionally, a chemistry lesson implemented by the each teacher was observed prior to the study. There were two workshops described in the study as one being a pilot study. The workshops lasted for 9 weeks included lectures such as Introducing Argument, Managing Small Group Discussions, Teaching Argument, and Resources for Argumentation, Evaluating Argument, and Modelling Argument that were taken from the IDEAS in-service materials developed by Osborne, Erduran and Simon (2004). After the workshops, post-interviews with the participant teachers were conducted and they were asked to implement 3 argumentation-based chemistry lessons for 45 minutes-each. The results of the study revealed that pre-service chemistry teachers had difficulties in some aspects of argumentation, such as planning argumentation-based lessons, constructing problems appropriate for argumentation, and modelling argumentation. Similarly, in-service chemistry teachers had difficulties in the planning argumentation-based lessons in terms of preparing appropriate instructional tools and materials. In the post-interviews, pre-service chemistry teachers attributed their difficulties to the lack of argumentation opportunities in their own courses and insufficient content knowledge. Chemistry teachers, on the other hand, attributed the difficulties they have faced with to the lack of their experience in preparing instructional materials for argumentation, and to the failure of students to try to sustain discourse. As regards the construction of counter arguments, teachers have linked the difficulties they experienced to their insufficient instructional strategies that are commonly used in science classrooms, such the question-answer method. The participant teachers stated that argumentation creates an environment for students to question their knowledge, ensures students' meaningful learning, and provides students with cognitive and social skills. The researchers concluded that the teachers' lack of experience in teaching argumentation-based lessons makes difficult for teachers to transfer theoretical knowledge learned in workshops programs to real science classes (Yıldırır & Nakiboğlu, 2013).

Another recent study focused on three student teachers' experiences of the teaching science as argument, their reflections, and the influence of context as a single case study (Barreto-Espino, Zembal-Saul, & Avraamidou, 2014). The study based on the conceptual framework "Teaching Science as Argument", which was concentrated on scientific content and enriched it with practices, such as inquiry, discourse, explanation, and reasoning. Participants were enrolled in a Professional Development School (PDS), where courses offered involving the introduction of conceptual framework, an electronic environment and reflective practices for specific cases. The data were collected via pre-interviews, weekly reflections, and post-interviews. The researchers reported that the opportunities in the PDS for teachers to interact with a science phenomenon and collecting data through experimentation increased the construction of evidence-based explanations. In conclusion, the framework teaching science as argument was a major leverage in PDS because it helped to reveal and coordinate fundamental features of teacher development in argumentation by mapping ways to reflect a clear, research-based framework among theoretical ideas and professional development courses (Barreto-Espino, Zembal-Saul, & Avraamidou, 2014).

Supovitz and Turner (2000) identified that engaging teachers in concrete teaching tasks as critical to high-quality professional development. The educational literature emphasize the presence of opportunities for both in-service and pre-service science teachers to engage in tasks that are meaningful for them in their teaching contexts (Jiménez-Aleixandre & Erduran, 2008). On the other hand, Zohar (2008) argued that designing adequate learning activities on argumentation is necessary but not sufficient to promote students' thinking and argumentation for themselves. As well, teachers should be provided with appropriate pedagogical knowledge in the context of teaching higher order thinking, including argumentation because while teachers engage their students in argumentation and in evidence-based reasoning, they also should promote explicit discussions about what a sound argumentation is (Zohar, 2008). Hence, the training of teachers in the context of argumentation should include the components that have the potential to create a shift in the normative nature of classroom discourse (Duschl & Osborne, 2002).

Components of teacher education on argumentation

The change in the teaching of science as argument could be achieved first of all by the shift in science teachers' understanding of argumentation as a critical component of learning of science (Duschl & Osborne, 2002). Teachers' understanding of what counts as argument might be reflected in their individual differences in emphasis on different kinds of argument structures that they constructed during any discourse (Erduran, Simon, & Osborne, 2004). Erduran et al. (2004) reported that interviews conducted with teachers revealed the beliefs teachers hold on argumentation, and teachers' argumentation was more sophisticated as their understanding of argumentation improved. Several researchers also underlined that the realization of an epistemological shift is possible by focusing on issues, such as how we know what we know, why we believe what we know, what we should do to find out, how knowledge is communicated, represented, and argued in science, the components and characteristics of a strong argument, the role and the nature of evidence in scientific arguments, as well as when and why we need to construct arguments in science (Erduran & Dagher, 2007; Sampson, Grooms, & Walker, 2011; Zohar, 2008).

Zohar (2008) pointed out that in teaching argumentation, the teacher need to help students move constantly between a cognitive level of thinking, which is argumentation about specific science content, and a meta-strategic level of thinking, which is about the rules and generalizations regarding argumentation. Thus, teachers required to be able to model the use of argumentation in variety of contexts and provide students with opportunities to communicate the cognitive processes they used during argumentation (Zohar, 2008). To do so, Zohar (2008) suggested that teachers should be introduced to the components of meta-strategic knowledge that they would use during argumentation, and also to the instructional ways for addressing these knowledge in the classroom.

The insufficient pedagogical knowledge and strategies to promote students' argumentation have been identified as a fundamental difficulty for teachers in implementing argumentation in science classrooms (Driver, Newton, & Osborne, 2000; Zembal-Saul, Munford, Crawford, Friedrichsen, & Land, 2002). Thus, the teachers would require a range of appropriate pedagogical strategies and materials in addition to the pedagogical knowledge in the context of argumentation in order to have a practical guidance, initiation and support to integrate argumentation in their science teaching (Duschl & Osborne, 2002; Erduran, Simon, & Osborne, 2004; Osborne, Erduran, & Simon, 2004; Zohar, 2008). However, Zohar (2008) warns that

> "Pedagogical knowledge in the context of teaching thinking and argumentation is tightly related to teachers' underlying theory of instruction. Therefore, …TE and PD programs …need to pay attention to teachers' knowledge and beliefs about teaching thinking to low-achieving students and to metacognitive issues pertaining to argumentation..." (p.264).

The duration of the teacher education programs is also a major issue to consider because of the shift that is intended to be achieved in the pedagogies that teachers use. Zohar (2008) suggested that the programs must be of a considerable duration, so that teachers find the support and feedback they need, especially in their first attempts to teach science as argument. Other research-based suggestions Zohar (2008) made for teacher education programs include the presence of an environment that would support reflection and feedback; involving teachers in the construction of instructional resources that they would employ to foster argumentation so that teachers feel ownership of the learning process and understand the associated educational goals; reflecting the pedagogies of teaching argumentation in the implementation of teacher education programs so that teachers should have numerous opportunities to engage in argumentation concerning variety of science topics; and including the theoretical background that would explain the underlying philosophies in the program (Zohar, 2008).

Kolsto and Ratcliffe (2008) emphasized the teacher's awareness of the complexity of the context of argumentation. The context of argumentation involves dialogues between different parties (student-student, teacher-student, small groups and whole-class) on a variety of aspects of phenomena, thereby the context requires evaluation of reliability of evidences presented as well as experts' reliability; understanding science-society interactions and awareness of social aspects of science; and interpretations of the tasks and their goals, which altogether might influence the development of students' learning. Therefore, in support of teachers' management of the complexity of this context, teacher education programs may offer more insight into ways of facilitating argumentation in different types of dialogues (Kolsto & Ratcliffe, 2008).

To sum up, in line with our knowledge of teachers' professional development, research suggested that teacher education programs (1) to include argumentation modules and guidelines developed for long-term use, and allowing teachers to practise, and to be involved in argumentation; (2) to support teachers in the introduction of argumentation to their classrooms by means of providing contexts which support reflection and feedback, such as teacher networks; (3) to introduce, produced, translated or adapted appropriate resources in order to support teachers in the introduction of argumentation in science teaching (S-TEAM, 2010). Moreover, to help teachers progress in their teaching of argumentation, Simon, Erduran, and Osborne (2006) suggest that the focus of professional development on argumentation should be on teachers' existing understanding of the importance of evidence and argument in science and on their implicit goals of teaching and learning science.

3.3.2. Frameworks for teacher education on argumentation

With the aim of constructing an educational design, which is a graduate course for teaching and learning argumentation, I collected a set of design solutions that were constructed and implemented by other researchers for extended periods of time. In the following, I described the frameworks in detail.

Minding Gaps in Argument

"Mind the Gap: Bridging Policy, Research and Practice" was a FP7 project funded by the European Union. "Minding Gaps in Argument" was a continuing professional development program, which involves a series of workshops that were developed as part of the project by researchers Erduran and Yan (2009). The program was implemented with 6 secondary science teachers in collaboration with researchers.

The researchers identified the aim of the programme as involving teachers into the action of closing the gaps that exist between educational policy, research and practice in regard to scientific inquiry and argumentation (Erduran & Yan, 2009). The reason behind this action was the emergence of these themes through the "How Science Works" component of the national science curriculum. Therefore, in line with the curriculum, the key goals of the project were stated as the following:

> "• To develop a CPD agenda on a relatively new aspect of the curriculum in order to bridge the policy-practice gaps;
> • To draw from existing research literature to contextualise the role of argumentation in science and in science education;
> • To generate some example student resources that can be useful for other teachers;
> • To explore exemplars of the implementation of "How Science Works" and argumentation activities in science classrooms;
> • To investigate the impact of the CPD agenda on the teachers' professional development" (Erduran & Yan, 2009, p. 1).

After the professional development program, a booklet and a DVD that highlighted some of the strategies used in order to achieve these goals were published. In the booklet, there were a description of the CPD model; the activities conducted collaboratively by the teachers and the researchers; and some example lesson resources. These were accompanied with some video footage and a set of video clips given in a DVD to illustrate the various aspects of the program and its impact on the teachers. In DVD, also the aspects of the professional development were summarised including how the teachers addressed the curriculum context by means of the strategies such as evaluating and reflecting on peer teaching that were used in the program (Erduran & Yan, 2009).

Erduran and Yan (2009) indicated that the program was guided by the principles of collaborative action with peers and researchers as well as teachers' reflective inquiries into their practices. The participating teachers, who were experienced and specialized in teaching physics and chemistry, were volunteered for the project when they were informed about the project by the letters sent to their schools.

During the program, teachers were engaged in three workshops. Each workshop was initiated by researchers based on the research evidence on the teaching of argument, and contributed by teachers in terms of classroom learning and teaching practices. The workshops were implemented by carrying out variety of activities including group discussions and presentations (Erduran & Yan, 2009).

The researchers initiated each workshop with a different theme. For example, the first workshop was framed by the conversations aimed at engaging the participant teachers in a discussion of gaps between research, policy and practice in inquiry-based science teaching. The workshop was supported with some research findings and lesson resources. Based on the conversations in the first workshop, teachers were asked to design and implement some inquiry-based lessons with the component of argumentation. Between the workshops, the teachers videotaped their sample lessons and these videos were shared during the workshops. In the second workshop, teachers shared their experiences in these lessons and the researchers had further input some other aspects of argumentation such as assessment and writing of argument. In the last workshops, the teachers in collaboration with the researchers further built on their experiences through reflection. The teachers mainly encouraged to reflect upon the issues and problems stemming from their practice. The researchers generally acted as critical colleagues and facilitators, and provided research evidence and resources for teaching (Erduran & Yan, 2009).

The program had several impacts on teachers. For example, teachers indicated that the opportunity to exchange their experiences and collaborating with other teachers across different schools facilitated a friendly environment and encouraged them to critically and reflectively exchange and communicate. The teachers also stated that they enjoyed the structure of the program in terms of its teacher-oriented focus. The researchers' support during the program encouraged them to explore their interests in their own teaching, created a sense of "ownership", and motivated them to take a step towards reconsidering their pedagogies. Moreover, the researchers reported that during the workshops, the teachers appreciated the benefits of teaching and learning of science via argumentation; the teachers' awareness and perception of the importance of argumentation were raised (Erduran & Yan, 2009).

The main activities in the workshops were as follows:

Workshop 1

- The aims and objectives of the project
- Discussion on how science works
- Sharing experiences with the curriculum
- Highlighting the Toulmin's model of argument

Workshop 2

- Sharing resources such as teaching strategies and lesson materials they produced

- Reflection on their own and peers' teaching
- Exploring assessment criteria for argument
- How Toulmin's model can be transformed for purposes of assessment

Workshop 3

- Supporting writing argument
- Mapping written argument framework in pairs

Science Teaching Advanced Methods

The project "Mind the Gap: Learning, Teaching and Research in Inquiry-Based Science Teaching" led to another project called "Science Teaching Advanced Methods", which was also funded by the European Union. The frameworks developed in the project for supporting argumentation in science teaching and learning resulted in teaching and learning resources produced in three countries involved in the project: France, Spain and England.

These resources and exemplar vignettes were documented on a report, which focused on various aspects of teaching and learning of argumentation as well as communication in science classrooms. The issues, such as those related with curriculum, instructional approaches and learning environments were also discussed in the report. The aim of the report was stated as providing a set of guidelines for argumentation and communication in secondary science classrooms, along with some examples on the implementation of the guidelines.

The resources from Lyon, France were introduced by Tiberghien, Vince, Coince, and Malkoun (2011). The researchers designed the resources through a design-based research, which was described in detail as a research article (Tiberghien, Vince, & Gaidioz, 2009). The design process involved the epistemological analysis of physics modelling, hypotheses regarding the learning and teaching, and analyses of classroom practices (Tiberghien, et.al, 2011).

There were six documents, each addressing a specific teaching component. For example, the first one was associated to global organisation and management of classroom. The next three was about the critical teaching components, such as explicit teaching of physics or chemistry modelling processes; prioritizing students' background; and considering the contexts of use for terms in physics. The last two documents were connected to the development of argumentation. "Organizing debate and institutionalising document" and "Making students cooperate in small groups" document dealt with debate in whole class that emerges when students presented their arguments to their peers under the supervision of teacher (Tiberghien, Vince, Coince, & Malkoun, 2011).

The structure of each session guided by the documents involved cognitive tasks like recall, exercise, problem, experiment, discussion, and debate, along with whole class, group work, and/or individual work. The documents were designed for teacher to read first the introduction, which is supposed to be proposed by a student on the difficulty of physics teaching for them and then perform a deeper analysis on a specific point (Tiberghien, Vince, Coince, & Malkoun, 2011).

The resources from Santiago, Spain were introduced by Jiménez-Aleixandre, et al. (2011). The researchers designed the resources based on an analysis of design principles for argumentation learning environments, which was described in detail as a book section (Jiménez-Aleixandre, 2008). According to the analysis, the argumentation learning environment is a type of constructivist and inquiry-based learning environment, where the evaluation of knowledge claims is particularly emphasized. The resources were also based on the analyses of classroom practices in terms of the development of the argumentation skills, such as competence in constructing arguments, use of evidence, and students' engagement in inquiry-based activities (Jiménez-Aleixandre, et al., 2011).

The purpose of the resources was stated as supporting teachers in their implementations of communication strategies and argumentation in the science classrooms in a more structured and explicit way because argumentation, communication and the use of evidence are components of inquiry-based science teaching (Jiménez-Aleixandre, et al., 2011).

There were four documents in the resources of Santiago, each addressing a particular teaching component. For example, Documents 1 and 2 were associated to specific student roles and argumentation practices that teacher is expected to support. Specifically, when focusing on inquiry, argumentation and evidence, the teacher is asked to help students to design and perform investigations while identifying, understanding and using evidence. Document 3 addresses the teachers' role in inquiry and argumentation as guiding and modelling scientific inquiry. The last document was about the design of curriculum for stimulating inquiry and argumentation by means of resources consisting authentic scientific inquiry tasks (Jiménez-Aleixandre, et al., 2011).

The resources from Bristol, United Kingdom were introduced by Erduran and Yan (2011). The researchers designed the resources based on the activities of a continuing professional development program that was the first framework introduced in this section (see Minding Gaps in Argument, p.147). In this program, the aim was to bridge gaps between research, curricula and professional development of secondary science teachers in the context of argumentation (Erduran & Yan, 2011).

There were four documents in the resources of Bristol, each addressing a particular teaching component. For example, document related with communication and persuasion addressed “how important as well as necessary is to integrate communication and persuasion activities in science teaching” in order to expose and engage students in communicative actions. ‘Setting tasks to produce a diversity of outcomes’ document was associated with designing authentic classroom activities and the teachers’ difficulties in the design and management of such activities. There were practical suggestions provided by researchers and exemplified in collaboration with teachers’ implementation of science experiments. The document about defining and representing science in context included the social, historical and philosophical dimensions of science. In this document, the issues regarding the impact of socio-historical and philosophical contexts on students’ understanding of science and learning scientific concepts. Again, the challenges that teachers faced with in the teaching of such approaches were discussed and practical suggestions were provided through a classroom debate activity. The last document was associated with sharing mutual responsibility for knowledge construction in the classroom. The focus in the document was on the science learning environments that promote shared and mutual responsibility during the construction of knowledge between the teacher and the learners. There was an example of an open-ended inquiry to illustrate the ways to empower students by giving them autonomy in their own learning (Erduran & Yan, 2011).

The main activities in the workshops were as follows:

Lyon Resources

- Document 1: global organisation and management of classroom
- Document 2: should have always in mind when teaching: making explicit the physics or chemistry modelling processes
- Document 3: taking into account the students’ prior ideas
- Document 4: taking into account the contexts of usage of physics terms
- Document 5: Organizing debate and institutionalising
- Document 6: Making students cooperate in small groups

Santiago Resources

- Document 1, about how teachers support particular students’ roles and practices, focuses on inquiry and argumentation: helping students to design and carry out investigations.

- Document 2, about how teachers support particular students' roles and practices, focuses on evidence: supporting students in identifying, understanding and using evidence.
- Document 3, about the teachers' roles in inquiry and argumentative learning environments: guiding and modelling scientific inquiry.
- Document 4, about the design of curriculum for promoting inquiry and argumentation: designing curricula and resources that consist of authentic scientific inquiry

Bristol Resources

- Document 1: communication and persuasion: the importance of integrating communication and persuasion activities in science lessons as well as the necessity of exposing and engaging students in a range of communicative actions.
- Document 2: setting tasks to produce a diversity of outcomes: the importance of designing authentic classroom activities with a diversity of outcomes and the challenges that teachers faced in terms of design and management of the related lessons.
- Document 3: defining and representing science in context including the social, historical and philosophical dimensions of science: issues of impact of socio-historical and philosophical contexts of science on students' understanding of nature of science and learning the scientific concepts.
- Document 4: Sharing mutual responsibility for knowledge construction in the classroom: importance of creating science learning environments that encourage mutual responsibility for knowledge construction between the teacher and the learners.

Argumentation-focused Chemistry Teaching

"Argumentation Focused Chemistry Teaching" course was developed by Tümay (2008) as part of a doctoral research. In the course, the researcher focused on first, the characteristics of a strong argument, the role of argumentation in science and science education; and second, the achievement of the knowledge and skills regarding integration of argumentation into high school chemistry lessons. The researcher developed the course based on the socio-cultural theories of learning as well as research evidence supporting the importance and the role of argumentation in science and science education. The course was the combination of several frameworks derived from the literature, including the IDEAS pack (Osborne, Erduran, & Simon, 2004), and the studies by de Berg (2006), Niaz (1998), Keogh and Naylor (1999) (cited in Tümay, 2008).

The course was 10-weeks long with three hours per week. Each session was associated to a specific argumentation teaching component, namely, Argumentation in Science and

Science Education, Small Group Discussions in Argumentation, Strategies for Implementing Argumentation in Science Education, Modelling Argumentation and Supporting Written Argumentation, and Evaluating Argumentation (Tümay, 2008).

The first one is related to argumentation in science and science education. Four documents in this session dealt with the components like the definition of argumentation, the role and importance of argumentation in science and science education, the elements of argumentation, and constructing arguments. The pre-service teachers participated in several activities throughout to achieve the goals of the session. For example, the researcher initiated a competing theories activity about the relationship between reaction rates and temperature for pre-service teachers to utilise science writing heuristic in small and large groups, as well as to think about their experiences in terms of the characteristic of a strong argument. In another activity, the pre-service teachers were provided with basic claims of chemistry, such as matter is composed of particles, and they were asked to justify the claim with appropriate evidence in small group and whole-class argumentation. The aim of this activity was to help pre-service teachers to share their viewpoints on designing argumentation focused chemistry lessons and on the required teacher knowledge and skills for the implementation of these lessons. Moreover, as part of the first session, the researcher used vignettes derived from history of science and role-playing activity for the discussion regarding the role of argumentation in science and science education (Tümay, 2008).

Session 2 was more pedagogy oriented in terms of the discussion about the role of small-group argumentation in science education. The pre-service teachers were trained on the strategies to organize and manage with small-group argumentation. The activity performed for this session was the use of concept cartoons. In the next session, specific teaching strategies to integrate argumentation into chemistry lessons and to establish and maintain a classroom culture that is more aligned with argumentation were proposed. The strategies that were introduced to pre-service teachers in this session involved predict-observe-explain, discussion of misconceptions derived from the chemistry education literature, and concept maps (Tümay, 2008).

The topic of the session 4 was modelling argumentation and supporting written argumentation. The per-service teachers engaged in discussion regarding the characteristics and structure of a strong argument as well as how to model an argument with its components in their classrooms. One unusual feature of this discussion was the emphasis put on the rebuttals. The second part of the session was devoted to the argumentative writing frames, which support the use of rebuttals in argumentation. The evaluation of these written argumentation as well as oral argumentation was the topic of last session. The pre-service teachers evaluated sample arguments derived from the argumentation in science education literature based on criteria they developed. Later, they were asked to employ the criteria they developed to evaluate sample students' argumentation and to think about how to scaffold students' argumentation (Tümay, 2008).

The researcher acted as a guide throughout the course in addition to his role of being facilitator. The small and whole-class collaborative work and social communication were supported during the intervention. The researchers also collected artefacts, such as journals kept all through sessions by pre-service teachers to keep record of their learning, their viewpoints related to the role of argumentation in science education, and the changes in their understanding of the goals of chemistry lessons (Tümay, 2008).

The main activities in the course were as follows:

1. Argumentation in Science and Science Education: *a competing theories activity about the relationship between reaction rates and temperature; activity about basic claims of chemistry, such as matter is composed of particles; vignettes derived from history of science and role-playing activity*

a. What is argumentation?
b. The role and importance of argumentation in science
c. The role and importance of argumentation in science education
d. The components of argumentation and constructing arguments

2. Small Group Discussions in Argumentation: *activity for the use of concept cartoons*

a. The role and importance of small-group argumentation in science education
b. Strategies to organize small-group argumentation
c. Strategies to manage with small-group argumentation

3. Strategies for Implementing Argumentation in Science Education: *predict-observe-explain, discussion of misconceptions derived from the chemistry education literature and concept maps*

a. Specific teaching strategies to integrate argumentation into chemistry lessons
b. How to establish and maintain a classroom culture that is more aligned with argumentation

4. Modelling Argumentation and Supporting Written Argumentation: *argumentative writing frames*

a. Modelling argumentation

b. Modelling counter-positioning in argumentation

c. Supporting written argumentation

was the topic of last session. The pre-service teachers derived from the argumentation in science education literature based on. Later, they were asked to evaluate sample students' argumentation and to think about how to scaffold students' argumentation

5. Assessment of Argumentation: *evaluate sample arguments, develop and employ criteria for assessment*

a. Assessment of written and oral argumentation

b. Scaffolding to enhance argumentation

Assessment and practical inquiry in scientific argumentation (APISA)

The Assessment and Practical Inquiry in Scientific Argumentation (APISA) resources were developed as part of a professional development project based in the Graduate School of Education at Bristol University and funded by the STEAM (Science Teaching Advanced Methods) project, which was funded by European Union FP7 Programme (Erduran, Yee, & Ingram, 2011). The resources described in the booklet by Erduran, Yee and Ingram (2011) focused on specific teaching strategies for teacher trainers to conduct workshops with science teachers, who are expected to teach scientific argumentation in secondary schools.

The first section of workshops was an introduction to argumentation, and the researchers aimed to engage teachers in argumentation by means of some exemplar activities. Providing models of argumentation in science teaching, the researchers illustrated the approaches for defining and supporting the teaching of argumentation in secondary schools. To begin with, the researchers suggested the introduction to Toulmin's model of argument in reference to scientific or socio-scientific examples. The next step suggested was developing a sense of ownership by means of allowing participant teachers to set the agenda for their own learning in comparison to the ideas introduced in the workshops (Erduran, Yee, & Ingram, 2011).

The second section was about aspects of inquiry-based teaching practices in science education. The resources were example teaching and learning practices generated by the teachers, who attended the workshops before. Sharing these classroom practices, strategies and pupils work, teachers engaged in discussions of scientific argumentation in practice. The section concluded with teachers developing their own new lesson plans for argumentation (Erduran, Yee, & Ingram, 2011).

The third section was designed to illustrate the national assessment framework and linking the objectives of the science classrooms with argumentation. Therefore, the trainers were suggested to focus on developing strategies for identifying clear learning objectives and outcomes for classroom activities in collaboration with teachers. The last section extended the work on assessment. In the fourth section, the different components on argumentation, practical inquiries and assessment were reconsidered in order to facilitate the coordination of these various aspects of teaching science. The teachers were asked to formulate strategies for and criteria of assessment of argumentation in science education. The session summarized and synthesized all the previous activities in the sessions by thinking through the ways that the quality of argumentation can be assessed in spoken and written argumentation in classes (Erduran, Yee, & Ingram, 2011).

All sections in the framework were introduced with their specific set of objectives, suggested activities that trainers may use in the workshops and resources that might be useful for the implementation of the sessions. At the end of the booklet, the researchers provided with example lesson resources and verbatim feedback from the teachers who participated in the project with the purpose to illustrate science teachers concerns in dealing with the proposed strategies in the workshops (Erduran, Yee, & Ingram, 2011).

The main activities in the workshops were as follows:

1. Introduction to argumentation

1.1. Introduction to argumentation in the context of scientific inquiry: *Video from mind the gap: Steve's runny honey lesson; Slides for session 1*

1.2. Strategies for defining and supporting argumentation: *A diagram of Toulmin's argumentation pattern; Example of a writing frame; Pedagogical strategies and ways in which argumentation can be used*

1.3. Developing a sense of ownership: *Flipchart to make a record of brainstormed ideas on models of professional development*

2. Ownership of professional development

2.1. Sharing teaching practices: *Videos of lessons pupils' resources developed by teachers*

2.2. Example teaching practices and reflections on lessons: *Teachers' descriptions of (a) the hearing loss lesson and (b) the wind farms lesson*

3. Practical inquiry and argumentation

3.1. Linking practical work in science with argumentation: *Set of worksheets illustrating practical activities; Getting practical session one power point; Session one practical audit grid*

4. Assessment, practical inquiry and argumentation

4.1. Assessment in argumentation: *Power point presentation on the aims of APP (assessing pupils' progress- protocol in England for teacher-based assessment in middle years education)*

4.2. Practical inquiry and assessment: *linking argumentation, assessing pupils' progress and getting practical: Power point presentation: 'why do we do practical work?'*

4.3. Assessing argumentation: *Video clip examples of pupil or whole class discussions; Analytical framework used for assessing the quality of argumentation; Examples in Erduran and Villamanan* (2009) *in the use of Toulmin's argument pattern in the assessment of written arguments.*

Promoting discourse and argumentation in science teacher education

Sadler (2006) designed this course specifically for pre-service middle and secondary science teachers as a part of their teacher education program at a large university. The course lasted 6 weeks long for 3.5 hour in-class and 40 hour out-of-class work per week. As part of the course, participants observed and participated in school science activities in middle and secondary schools. The course was composed of four sections: "instructional themes, classroom environment, explicit instruction, and facilitating argumentation" (Sadler, 2006).

The course began with a framework for science teaching; in which argumentation was one of the four basic components. The other three components: constructivist epistemology, inquiry, and critical thinking, were presented interdependently in the first and second sections of the course. In addition to these basic themes, the participants were also engaged in discussions regarding inquiry, nature of science, learning cycles, standards, misconceptions, safety, and instructional planning. By connecting all themes in a framework, the researcher aimed at modelling the development of a classroom community, which support the integration of argumentation in science education (Sadler, 2006).

The third section of the course was about explicit instruction about argumentation and discourse in general. The section was supported with excerpts from a research article related to strategies for promoting argumentation in school science. After theory building about argumentation, the participants examined the argument structure proposed by Toulmin (1958). The analytical tool based on Toulmin's model of argument structure was used to analyse a series of excerpts derived from science textbooks. The participants further worked through a series of practice exercises to evaluate evidence used to support claims, counter claims and theories, made decisions regarding the lines of evidence that best supported claims, and constructed arguments based on data and justifications. Once the participants recognized the characteristics of arguments with several components, the discussions about an argument's effectiveness with the suggestions for improvement of an arguments, the uses and limitations of data and evidence, as well as how values contribute to some argumentation contexts were held. The role of counter-positions and rebuttals in representing alternative perspectives to an argument was emphasized. One unique contribution of this framework was the inclusion of common reasoning fallacies that are prevalent among middle and secondary students. Additionally, specific suggestions for enhancing the quality of scientific and socio-scientific argumentation in classrooms were discussed by the researcher in collaboration with the participants. At the end of this session, the participants experienced argumentation in a jigsaw activity related to gene therapy designed for high school biology classes (Sadler, 2006).

The last section of the course was associated with facilitating argumentation. In this section, the participants designed and presented sample lessons with integrated discourse and argumentation component. In addition to these lesson plans, the participants were also engaged in activities, such as preparing an assessment rubric and a unit plan, to exemplify the incorporation of argumentation into science classrooms (Sadler, 2006).

The main activities in the course were as follows:

1st – 2nd week: Instructional themes: constructivist epistemology, inquiry, and critical thinking.

- A framework for science teaching: argumentation
- Other themes around which instruction were designed: nature of science, learning cycles, standards, misconceptions, safety, and instructional planning.
- Development of a classroom community that support argumentation

3rd week: Argumentation and discourse

- Discussion of excerpts from an article related to strategies for enhancing argument in school science (Osborne, J., Erduran, S., Simon, S., & Monk, M. (2001). Enhancing the quality of argument in school science. School Science Review, 82, 63-70.)

- Exploring Toulmin's argument pattern
- Analysis of a series of excerpts taken from secondary science textbooks to identify argument patterns.
- Discussion on how an argument's effectiveness can be improved with the inclusion of counter-positions and rebuttals.
- Presenting common reasoning fallacies that can undermine argumentation (Zeidler, 1997)
- Suggestions for enhancing the quality of argumentation in classrooms (Chesebro & McCroskey, 2002; Cooper & Simmonds, 2003)
- Students were challenged to construct arguments on a variety of scientific issues and discussed various strategies for structuring and encouraging student discourse in science classrooms.
- Exploration of how argumentation and discourse could be used in the context of science-technology-society or socio-scientific issues
- A jig-saw activity related to gene therapy (Sadler & Zeidler, 2004)

4th week: Sample lessons designed to highlight discourse and argumentation

- Preparation a series of lesson plans, an assessment rubric, and a unit plan

3.3.3. Initial attempts for a design solution

In light of the abovementioned frameworks, I searched for potential ways of implementing a professional development program for teachers. With this purpose in mind, I scheduled meetings with researchers and content experts as well as third parties from Ministry of Education, Department of In-service Teacher Training. In these meetings, I discussed my draft proposals considering the feasibility and viability of each, and checking the ones that seem the most promising.

The first draft proposal: A professional development program for teachers

In the first draft proposal, I stated my aim as to implement a continuous professional development program in order to foster the incorporation of argumentation in science lessons through the development and implementation of argumentation integrated learning designs, and to see the effects of the implementation of these learning designs on students' cognitive outcomes.

The learning design in this proposal refers to "an application of a pedagogical model for a specific learning objective, target group, and a specific context or knowledge domain" (Koper & Olivier, 2004, p. 98). It specifies the teaching and learning process, along with the conditions under which it occurs and the activities performed by the teachers and learners in order to achieve the required learning objectives.

The aim stated in the proposal and the research questions related to the aim were summarized in three parts: training teachers about argumentation practices and interactive learning designs for argumentation integrated courses; observation of participant teachers' science lessons and providing teachers with scaffolding during their implementation of argumentation and interactive learning designs in their science classes; and investigation of the effects of implementation of learning designs enriched with argumentation on student outcomes. As an intervention, my plan was to design a professional development program on argumentation with technology integrated learning design to improve teachers' skills on teaching argumentation as well as learning design skills related to argumentation and implementation of these learning designs in their science lessons.

In the development of a program, I based my design on the design experiment framework described by Gravemeijer and Cobb (2006). The framework involves three phases of conducting a design experiment: 1) preparing for the experiment, 2) experimenting in the classroom, and 3) conducting retrospective analyses (Gravemeijer & Cobb, 2006). From a design perspective, the goal of the preliminary phase of design research experiment is to formulate a local instruction theory, which was argumentation theory in my draft proposal. The theory can be elaborated and refined while conducting the intended design experiment, which was the development and implementation of learning designs related to argumentation though a series of continuous professional development workshops. The second phase consists of actually conducting the design experiment. I planned to take the responsibility for the learning process of a group of elementary science teachers and consequently, their students. The purpose of experimenting in the classroom was both to test and improve learning designs related to argumentation and to ensure the implementation of these designs in real science classrooms. A further aspect of the methodology was the retrospective analyses, which involve an iterative process of analysing the entire data collected both during continuous professional development stages and student outcomes.

Reflections on the first draft.

In the meetings held with my supervisor, the feasibility and viability of the draft proposal were evaluated. The main points of discussion in these meetings were how qualified I am in teacher training and professional development programs as well as in argumentation in science education and learning design; how to access to science teachers; who were supposed to be volunteers; how to convince teachers that such an argumentation-based learning design program is necessary for their professional development; how to finance the program and for how long the program would be; in addition to the design requirements for the learning design.

With regard to my experience, as the facilitator of the program, in teacher training and professional development of science teachers as well as in learning design practices, the final conclusion was that I am qualified in handling these programs because not only I took graduate courses related to teacher learning and teacher education, and published a master thesis on argumentation (Ozdem, 2009; Ozdem, Ertepinar, Cakiroglu, & Erduran, 2013), but also I had been involved in a number of national and international projects, as a teacher trainer or researcher, including professional development of teachers (Ozdem & Cavas, 2012) and learning design (Cavas & Ozdem, 2012).

To overcome the issues regarding the recruitment of science teachers and communication with them for the possible outcomes of the draft program, I contacted with the Department of In-service Teacher Training, at Ministry of Education, in Turkey. However, the involvement of teachers was only possible through a funded professional development project, or I needed to seek for individual volunteers who were able to devote after school time for such projects. Thus, the recruitment of teachers was a major problem because the professional development program I proposed was neither a part of a nation-wide project nor there was financial support to conduct after-school professional development program because such a program would at least require a centre to study.

Another difficulty was associated with the learning design. The mode of delivery for most of the learning designs are relevant to the use of Information and Communication Technologies (ICT), which focus on content and services (Britain, 2004). In this study, the plan was also to engage teachers in the use of computer-based Learning Design. The software for the program was designed and tested by a professional computer software programmer. Therefore, even in the second draft proposal, I did not give up on Learning Design.

Because of the difficulties experienced in the first draft, a second draft was formulated.

The second draft proposal: A graduate course for teaching and learning argumentation.

For the reasons that were explained in the reflections on first draft proposal, the professional development program was not possible. Hence, in this proposal, teachers' perceptions regarding the use of Learning Design (LD) environments by teachers in science education in general and in specific in argumentation integrated science lessons, and the role of argumentation in science education were to be investigated throughout a graduate level argumentation course. This change made in the proposal led to the removal of the goals regarding the student outcomes since regular address of the argumentation in school was not in the limits of the proposal.

In the second draft proposal, therefore, the aim was revised as to investigate and develop first, elementary science teachers' learning design that made greater use of argumentation in their teaching. Participants would develop their learning-design skills by creating learning activities into a workflow and a vehicle for the sharing and re-use of learning design patterns in schools. In addition, teachers would supposed to be trained to select appropriate learning-design tools that suit their own needs in terms of planning, implementing and sharing pedagogical ideas. As a continuum of this course, my interest in this proposal also laid in asking what kind of outcomes in teacher practice of argumentation could be achieved with this approach to teacher professional development.

In line with these aims, a graduate level argumentation course would be developed and implemented in order to foster the incorporation of argumentation in science lessons through the training of teachers about argumentation. This course was to serve as a comprehensive argumentation teaching module which aims at developing teachers' perceptions of argumentation integrated science lessons in the future.

Reflections on the second draft

The second proposal was evaluated with the dissertation committee members, who were three experienced researchers and content experts in the areas of argumentation in science education, teacher development, teacher learning, teacher beliefs, curriculum studies, higher education, and qualitative research. The main points of discussion were the pre-interview questions to explore the participants' views regarding the goals of the course, and hypothetical, developmental ideas about my expectations related to argumentation and learning designs as well as their interconnection.

Suggestions regarding the pre-interview questions were that they should be revised to be less academic in terms of language, address the idea indirectly, and be narrow and specific in meaning. It was also suggested to pilot-test the interview questions before implementation and revise them accordingly. Therefore, the pre-interview questions, especially the ones seeking for the participants' perceptions of argumentation, were revised. The questions were collected from argumentation studies in the literature. The pilot-testing of the interview questions were done with two graduate students. According to their understanding and their suggestions, all the questions in the pre-interview, including the ones related to learning design, were revised to their final version (see Pre-interviews to explore participants' understanding of the problem, p.114).

Another suggestion was to think about some hypothetical, developmental ideas about my expectations related to argumentation and learning designs as well as their interconnection. My hypothetical idea was that learning design system would assist science teachers in designing argumentation-based science lessons. My proposal was that learning design is a sustainable, long-term and open-to-development system that will assist teachers to adapt and be familiar to new instructional theories, models and designs (Duschl, 1990). Moreover, as suggested by Yan and Erduran (2008), argumentation can be taught through suitable instruction, task structuring and modelling through tools generated through information and communication technology (ICT). There are examples of ICT based platforms to help students learn more about or from scientific argumentation such as WISE and Belvedere (Clark, Stegmann, Weinberger, Menekse, & Erkens, 2008; Yan & Erduran, 2008). The proposition of this study, therefore, was that a similar ICT-based instruction, task structuring and modelling, that is Learning Design, could also be used to teach teachers how to design learning for argumentation. However, the integration of the software into a web-based platform could not be possible because of the technical issues, which took a long-time to resolve. Therefore, unfortunately, the Learning Design could not be delivered to participants for their use on time.

3.3.4. Construction of a design solution

Upon the reflections of the second draft proposal, the construction of a graduate level course on argumentation were initiated. The course proposal (see Appendix B. New Course Proposal, p.320) was generated based on the literature about argumentation in science education (see 3.2.2. Argumentation in science education, p.59) and teachers' learning (see 3.2.6. Teachers' Learning, p.133), needs of participant teachers (see Pre-interviews to explore participants' understanding of the problem, p.114) regarding argumentation, and as a synthesis of frameworks (see 3.3.2. Frameworks for teacher education on argumentation, p.147) described. In this section, the details of the course proposal submitted to the Graduate School of Social Sciences were explained in detail.

Objectives and main methods of the course

In the course proposal, the objectives of the course were stated that at the end of the course, the participants would be able to;

1. draw from existing literature to contextualize the role of argumentation in science and in science education;

2. identify some of the pedagogical strategies necessary to promote argumentation skills in science lessons;
3. trial the pedagogical strategies and to determine the extent to which their implementation enhances their pedagogic practice with argumentation;
4. provide students some example guidelines for structuring the lessons in ways that would support evidence-based reasoning to take place;
5. generate some example resources that can be useful for elementary science teachers to link ideas on scientific argumentation with coursework that includes practical investigations;
6. generate some strategies for and criteria of assessment of argumentation in science lessons;
7. develop an interest in research on argumentation in science education.

The main methods by means of which the course was to be conducted were identified as the presentations and discussions of articles and/or texts assigned; in class and out of class practical applications, such as hands-on/ minds-on in class activities and examples of out-of class lectures; sharing teaching practices and reflections on lessons videotaped, and preparation of evidence-based professional development portfolios.

Content of the course

The introduction to the course was twofold: introduction to the web-based support system for a teacher training program that will be used throughout the term, which was the Learning Design (LD), and introduction to communication and persuasion.

With regards to the LD, before the course, a Learning Design Needs Analysis Questionnaire was given to the participants and in the pre-interview, the participants were asked their experiences in the use of ICT based learning platforms. Because, in the final design, the LD component was removed, neither the results related to the questionnaire nor to the pre-interview regarding LD were given place in the section “Pre-interviews to explore participants’ understanding of the problem”. Nevertheless, to justify the integration of LD in the first design solution, these results were briefly described below.

At the beginning of the term, participants filled the Learning Design Needs Analysis questionnaire. The data provided evidence to participants’ inexperience in using web-based educational systems for designing instructional tasks. For example, three participants addressed their lack of knowledge in designing lesson online, and three participants pointed to their rare use of educational software to design a lesson. The needs analysis also gave idea in terms of what the online learning design platform should and should not have. For example; the participants indicated that time limitation is an important problem for alternative science teaching methods and any system should certify its efficiency in terms of designing the lesson in appropriate time.

Before the term began, pre-interviews with two of the participants, attending to the course in the first term, were done. In the pre-interviews, Hilal stated that she didn't use any online teaching material or web-based educational software to plan a science lesson. The only way she used online teaching and learning tools in her planning was for teaching experience course. In the content of the course, she planned science teaching several times and she downloaded usually pictures, simulation and/ or videos for teaching. She indicated that online discussion could be less efficient if it is done before class discussion. On the contrary, Can had a background especially in computer related fields. He attended to web-design and programming courses. He was involved in a project where he constructed a web-page to demonstrate educational materials and science laboratory videos. The project was called Virtual Science Centre. Therefore, he was familiar to the use of online learning objects. In conclusion, the different levels of experience the participants had led me to include introduction told in the first lesson.

Introduction to communication and persuasion was included at the beginning of the course because most of the participants were only familiar with discussion but not with any other discourse, including argumentation (see Pre-interviews to explore participants' understanding of the problem, p.114). Therefore, the importance of integrating communication and persuasion activities in science lessons as well as the necessity of exposing and engaging students in a range of communicative actions were emphasized in the content of introduction.

The course was divided into six sections. The first section was aimed at developing a basic understanding of argumentation as a concept, and contextualizing the role of argumentation in science and in science education drawing from existing literature. For this purpose, in this section, the definition of argumentation, the importance and role of argumentation in science and science education, and an introduction to argumentation in the context of scientific inquiry was included. The second section was about the strategies for defining and supporting argumentation. In the design solution, before the strategies, a diagram of Toulmin's argumentation pattern, and analysis of a series of excerpts taken from elementary science textbooks to identify argument patterns were planned in this section. Following the analyses, pedagogical strategies and ways in which argumentation can be used were included in the draft, along with a discussion about how to support students in identifying, understanding and using evidence; and how to enhance scientific argumentation by posing open questions. At the end of this section, design of learning with lesson plan and resources that consist of argumentation were targeted for a practice of LD.

The third section was designed to introduce written argumentation with strategies for supporting written argument, mapping written argument framework, and Science Writing Heuristic as a written argumentation framework. The next section aimed at linking practical inquiry in science classes with argumentation in conjunction with a discussion of teachers' role in inquiry and argumentative learning environments. In this section, a discussion on how teachers support particular students' roles and practices with a focus on inquiry and argumentation was included, and the practice of argument-driven inquiry model was intended.

In the design solution, I also put emphasis on argumentation in socio-scientific contexts. For this purpose, the exploration of how argumentation and discourse could be used in the context of science-technology-society or socio-scientific issues was incorporated into the course and a jig-saw activity related to gene therapy was planned. The last section was linked with assessment of argumentation in science education. The exploration of assessment criteria for argument and a Toulmin's Argument Pattern as an analytic framework were included in this section.

Planned tasks of the course

The course content was supported with the integration of tasks, such as readings or articles to be discussed, pre-activity discussions, activities, and post-activity discussions, as well as resources like videos, presentations, worksheets, lesson plans, analytical frameworks, and sample excerpts from students' argumentation derived from the literature (see Appendix C. Planned tasks for the course for weekly schedule, p.326).

Readings or articles were book chapters or high-reputation research articles published in educational journals. The participants were required to read each reading before coming to the class because the discussion was around the topics addressed in the reading. I selected the readings based on a specific aspect of argumentation that was to be addressed per week. Pre- and post-activity discussions were the main questions regarding these aspects. Activities and resources were selected from the frameworks investigated before the construction of the design solution; hence, they were empirically tested and reported in the products of these frameworks (see 3.3.2. Frameworks for teacher education on argumentation, p.147).

Furthermore, the participants were required to be actively involved by means of discussion questions that they were asked to send by e-mail to the list of recipients, including the researchers and the instructor, before the lesson. Discussion questions would be about the readings or any concern related to the content of the course. The aim was to involve teachers in the planning of the lesson in progress. By means of discussion questions and reflection papers, the participants had chance to define and transform the progress of the next lesson. This was a critical component of the course because this strategy allowed the participants to set the agenda, take responsibility of their own learning, engage with the aims of the course, and finally develop a sense of ownership (Erduran, Yee, & Ingram, 2011).

The design solution was empirically tested and I further reflected upon the findings in order to refine the theoretical understanding and the intervention. These evaluation and reflection on the first design solution and the improvements made in the cyclical process of the development of the design solution were explained in the following.

3.4. Evaluation and Reflection

During the evaluation and reflection process, I framed the inquiry into a course design and collected empirical evidence with regard to evaluation. The audio-recorded course sessions, post-interviews with the participants, meetings with my dissertation committee members, participants' written materials, their reflection papers related to their learning in each session of the course, and their statement of argumentation in three instances during the course were constituted the data as empirical evidence.

The evaluation and reflection in this study was a cyclical process where several iterative cycles were included until the refinement of a successful design solution was achieved. In other words, evaluation and reflection took place in the early assessment of the design solution to weigh how the theoretical ideas instantiated and were applied in the design as well as the applicability of the design in regard to the resources available and accessibility of the participants. During the implementation of the design, evaluation and reflection took place to test how the design worked in real context and at the end, to what extent the intervention achieved its intended construction purposes, that is, enhancing the participants' knowledge and skills related to the implementation of argumentation in science classrooms.

3.4.1. The evaluation of the initial design solution

The initial design solution, which was constructed based on the literature about argumentation in science education (see 3.2.2. Argumentation in science education, p.59) and teachers' learning (see 3.2.6. Teachers' Learning, p.133), needs of participant teachers (see Pre-interviews to explore participants' understanding of the problem, p.114)

regarding argumentation, and as a synthesis of frameworks (see 3.3.2. Frameworks for teacher education on argumentation, p.147), was empirically tested in the spring term of 2011-2012 academic calendar.

The researcher's role

In the evaluation and reflection process, I focused on explicating the independent realities and experiences of the participants, and myself, as a researcher. This positioning of myself in this methodology compelled me to act as a researcher and participant, and to observe myself as well as the participants (Schwartz-Shea & Yanow, 2012).

It was not easy to differentiate the roles as a researcher and a facilitator. During the empirical testing of the design solutions, I generated data through audio-recording of the interviews with the participants and meetings with my supervisor, thesis monitoring committee, and the participant observer; audio-recording of the class sessions; accumulation of all available artefacts, including the participants' worksheets, their reflections on each session, their statement of argumentation; and video-recordings of the participants' teaching practices in science classrooms. The data generation and analysis were my roles as researcher.

Besides, I acted as the facilitator of the classes. At the beginning of each session, I provided a brief overview of the readings, I summarized the schedule of the day, I participated in the discussions with the participants and shared my understanding, knowledge and experience with the participants, I modelled argumentation practices in class and in laboratory as a science teacher, I took part as a participant in the activities provided by the guest speakers, I provided guidance for the participants' planning of their teaching practices, and I provided feedback during their reflections on their teaching practices.

I was in close contact with the participants throughout the course; therefore, the mutual shaping influences were inevitable. For this reason, I wrote my reflections and I provided my changing perspectives throughout the study. However, in order to make the results clear for the readers, I mainly provided the participants' perspective in the results and my perspective in the reflections in the following. My changing perspective was provided in Chapter 5, p.269.

3.4.2. Results

Two of the participants, Can and Hilal were enrolled in the first term of the course and experienced the first design solution. The results covered their description of experiences written on their statements of argumentation in three instances of the course (beginning-middle-end), reflection papers per week and post-interviews (see Appendix D. Post-interview questions, p.337), as well as meetings with the supervisor and the participant observer, and audio records of the course.

Section 1. Introduction to argumentation

The objectives of the first section were to introduce argumentation, and to emphasize the importance and role of argumentation in science and science education. Also, an introduction to argumentation in the context of scientific inquiry was provided. Can and Hilal referred to different gains in their reflection papers regarding the first section of the course.

In her statement of argumentation (SoA), Hilal referred to *argumentation as a kind of discourse*, and *as a social practice*. Both of these descriptions of argumentation were intended in the content of the section. In her reflection paper (RP), Hilal wrote about a range of issues, which were part of the readings as well as in-class discussion, including the components of an argument, the role and importance of argumentation in science education, and the ways to engage students' in argumentation practices. For example, in terms of the attainment of the goals of science education, she wrote that

> "In this sense, since argumentation is the social practice of science, it should be used as the core of science education as it is for the scientists. This, in turn, will enhance the public understanding of science and improve individuals' scientific literacy." (Hilal, RP-2, p.1, lines (l).11-14)

As regards to the structure of an argument, Hilal just wrote about *the importance of justification in an argument* in her statement of argumentation.

> "On the other hand, the main difference between the argumentation and discussion is that argumentation requires justification" (Hilal, SoA-1, p.1, l. 5-6)

However, in her reflection paper, she gave a detailed description of *all components of argumentation*;

> "The explanations and examples were very useful for me to learn the components of a complete argument. As an example, we used the claim "Harry is British". For the claim, we thought about possible data (evidences), justification (warrant and backing), qualifier, and rebuttal. In the lecture hour, it was emphasized that rebuttals are very crucial. They are generated against the counterarguments that one asserts opposing to our arguments... One of the reasons behind this idea may be that, it is not difficult for a person to generate an argument from his/her

> point of view but it is most of the time difficult to disprove another people's point of views. Here, people should use different perspectives, and think critically to create rebuttals against the counterarguments." (Hilal- RP-2, p.1, l.16-25)

Can defined *argumentation as a kind of discourse* and *as a process* as well as a teaching method both in his reflection paper and statement of argumentation. As regards to the importance and role of argumentation in science education, Can focused on the *wider goals of science education* in his reflection paper. For example, he wrote that

> "There are many ways to apply science education in terms of democracy and citizenship education. Argumentation is one of the teaching methods to provide students with the conception of democracy. For instance, argumentation process includes interaction between students. Each student should learn other students' ideas and opinion about specific content. Moreover, they should evaluate other ideas and find acceptable and unacceptable aspect of each. As a result of this situation, student will be respectful towards all the opinion in their life. They will listen to speech of people they face without any prejudice towards them. Moreover, students support an idea and find evidence to support this idea. As a result of this they are aware of why they have to support an idea or why they should not support. They will understand advantages of democracy both for them and communities." (Can, RP-2, p.1, l. 19-28)

Regardless of how broad or specific goals of argumentation in science education were addressed in participants' reflections, I can say that section 1 provided a rationale to integrate argumentation in science classrooms, along with an understanding of what argumentation is.

Upon the completion of section 1, we held a meeting with my supervisor. In this meeting, we evaluated how responsive the participants were and how effective the section was. My supervisor noticed that the participants were attentive to the class with questions and comments. They were ready to learn the theory but because English was their foreign language, it was difficult for them to grasp the meaning of the terms in this language. In this case, switching to Turkish and providing content-dependent and content-independent examples to apply the theory in practice were two options that were effective. By doing so, the participants were more focused and enthusiastic about learning (J.C. - feedback, 23.03.2012-10:53, duration: 12.37 min.)

Section 2. Strategies for defining and supporting argumentation

Section 2 was implemented in two weeks (6 hours in total). The section was planned to be started with an introduction to Toulmin's Argument Pattern. However, in the discussion questions sent by the participants before the course, there was a concern about the difference between evidence and justification. The activity and subsequent discussion increased awareness in regard to the construction of scientific knowledge. For example, Hilal stated that

> "There were an activity which requires writing some evidences and justification according to the given claim. As PhD students, we even had difficulties in writing evidence and justifications. That is also true for most of the elementary and high school students. The reason might be that we do not know the exact difference between evidence and justification. Evidence is data, observation or a real-life example is to proof the claim while justification is the explanation of why this evidence explains this claim. In order to make individuals gain the skills of qualified argument generation and know the component of an argument, science education should aim to design instructional contexts which supports scientific argumentation." (Hilal, RP-3, p.2, l. 33-41)

A guest speaker, Dr. Halil Tümay was invited to share his experiences with pre-service teachers in the course of Argumentation-focused Chemistry Teaching (Tümay, 2008) (see Argumentation-focused Chemistry Teaching, p.153). Dr. Tümay addressed the pedagogical strategies he modelled in the course. Hilal was attentive to this presentation and she also wrote about the presentation in her reflection paper;

> "Finally, we have a guest speaker who completed his PhD study on pre-service chemistry teachers' perceptions on argumentation regarding its use in science education. Inviting such guest speakers to the course is very useful for us to see the current research studies conducted in this area. Thanks to this presentation, we had chance to discuss on a case study related to argumentation with a sample of pre-service teachers." (Hilal, RP-3, p.2, l. 42-46)

Although Can referred to the invited speakers in the post-interview, his reflections for this section were pertaining to his views about the readings.

Section 3. Written argumentation

Section three was about written argumentation. For this section, a guest speaker, Dr. Murat Günel was invited to share his experiences with teachers in the project of

Argumentation-Based Science Learning (Günel, Kıngır, & Geban, 2012; Kingir, Geban, & Gunel, 2012). Can referred to this presentation in the post-interview (PI);

> "Q: What would be your suggestions for the next term?
>
> Can: …Moreover, the guest speakers were really helpful. The seminar was particularly effective. We became familiar to other studies in the area and the attitude of teachers was really stunning since this issue was such an important one to raise our awareness about argumentation." (Can, PI)

However, none of the participants reflected upon the writing frameworks introduced in the class. The reason might be that the seminar provided by the guest speaker was more intriguing for the participants because the real classroom experiences of teachers, who were involved in the project, were presented by the guest speaker.

Nevertheless, I witnessed to the shifts in the participants' understanding of argumentation after this section by their second statements of argumentation, which were submitted subsequent to this section. For example, Hilal emphasized *the presence of plural accounts and rebuttals* as well as their role in *promoting higher-order thinking* in her second statement of argumentation assignment;

> "…a student who engages in argumentation should propose reasoning that why this evidence explains this claim…. However, there might be completely different point of views. Here, the other student may generate a counterargument which is opposite to the first students' arguments. As far as I understand from my readings, this point is very important. Because for and argumentation to be qualified and high level, here, the first student should rebut the second students' counterargument. That means that rebuttals are accepted as the indicators of high quality argumentation. According to me, the reason might be that, every one may generate arguments from his/her point of views but thinking from others' eyes may sometimes be difficult and requires multi-perspective thinking. Thinking from multiple dimensions requires high level knowledge and high level reasoning." (Hilal, SoA-2, p.1, l.4-5, 7-16)

Similarly, Can focused on the structure of an argument in his second statement of argumentation. More importantly, in this assignment, Can tended to see *argumentation as a core process of science*;

> "Argumentation is core of the science because argumentation process and scientific process are almost the same. Scientific discussion between Einstein's theory of relativity and Newton's principle is impressive example to explain exactly

association between argumentation and science and why argumentation is core of the science. What scientists do is the same with what we want from students. Therefore, science lesson would be rich with integration of argumentation." (Can, SoA-2, p.1, l. 9-14)

Section 4. Practical inquiry and argumentation

Section four was implemented in two weeks (6 hours in total). Argument-driven inquiry was modelled as an example to linking practical work in science with argumentation. The participants experienced the process by hypothesizing, experimenting, communicating, and sharing their results. All through the process, argumentation was promoted by prompting questions, such as why do you think this experiment would work, how do you explain your data, why do you think your data supports your hypothesis, how would you explain the results of the other group, and what do you think is missing in data or in the final argument; as well as by argument-driven inquiry framework, including interactive poster session, investigation report, and peer review (Sampson, 2009). Experiencing a scientific investigation through argumentation was exciting but compelling for the participants. For example, Hilal reflected that

> "The most difficult part for the groups was the reasoning part. We had difficulty to express our justification to show the reasonable relationship between our explanation and evidence and the reason why our evidence support our claim (explanation). Through this activity, we saw that it is not always easy to justify the scientific claims. Even we are, as doctorate level students, faced difficulties in the reasoning process. Hence, science should be taught through a process that includes claim, evidence, and justification, reasoning so that students may go deep into the concepts and develop skills to generate arguments." (Hilal, RP-6, p.1, l. 18-25).

Can was in agreement with Hilal in that although experiment was very simple to conduct, constructing an argument was not easy. Can thought that their difficulty was pertaining to their lack of adequate knowledge in the topic, or their misconceptions. Nevertheless, Can was in the opinion that prior knowledge is not always a prerequisite for argumentation based on his experience. He indicated that

> "I am of the opinion that theories, laws, models, concepts are not essential for argumentation. Logically, if it was necessary, first scientist in the world would not explain any problem using argumentation process which is core of the science because there were no theory or model yet. For instance, Democritus who is an ancient Greek philosopher firstly justified that everything is composed atoms.

Another ancient Greek philosopher Aristoteles firstly argued that all planets include sun revolve around the world. Since he clearly justified his claims, his ideas were accepted during medieval times. Consequently, teachers should not take into consider students' knowledge concerning conceptual structures and should not give up apply argumentation due to lack of students' knowledge. Eventually, students will attempt to explain problem situation they face." (Can, RP-5, p.1, l. 17-26)

Section 5. Argumentation in socio-scientific contexts

Argumentation in section five was contemplated to be modelled through a jig-saw activity related to gene therapy. However, in our meetings with my supervisor, we thought that a local socio-scientific issue, which was on the agenda of the people at the university and the city we live in, would be more intriguing for the participants and incorporate more participants into argumentation. For this reason, we picked the controversial issue of public access to Lake Eymir, which was allocated to Middle East Technical University campus in 1956. There are regulations that apply to visitors of Lake Eymir. For example, people, who are not METU employees and students, have to pay for an entrance card to access the lake area. This restriction was a controversy between two parties: On the one side, the metropolitan mayor argued that a lake cannot be a property of a university, and entrance to a lake area, as to university campus, should be free of any charge. On the other side, the university administrators argued that the restrictions and other regulations are for protecting the nature and ecosystem of the lake area, which was once only a great marsh and had chance to survive only if the precautions are taken and applied carefully. This controversy was the hot topic of the month and there were many resources, such as journal articles, research articles, news, and interviews with all related parties. Therefore, the socio-scientific argumentation was initiated with the introduction of this issue and asking for the argumentation of individual participants.

The participants' reflections on the class illustrated that the main features of socio-scientific argumentation were clear in their experience. For example, Can stated that

> "Although there is no clear cut solution of current issue, we chose a claim, found evidences and data, rebutted other groups' claims as previously we had done. Furthermore, our much evidence did not base on scientific facts. Sometimes we chose different type of knowledge sources. …Socio-scientific issues provide understanding of life. Students notice that scientific knowledge sometimes cannot achieve solving problems we face. They use other sources of knowledge such as moral, religion, and aesthetic." (Can, RP-6, p.1, l. 6-7, 13-15)

In addition, Hilal noticed the advantages of arguing on a local controversial issue;

> "One thing that is very remarkable here is that the issue is a local issue. Hence, we all had some idea about the issue since it is Eymir Lake is within the borders of our university. That's why we did not face difficulty to discuss about our position. Therefore, using local socio-scientific issues may enhance students' informal reasoning since they are familiar to the issue in their daily lives." (Hilal, RP-7, p.1-2, l. 22-27)

Section 6. Exploring assessment related to argumentation

In section 6, the participants were presented assessment frameworks derived from the literature and a discussion on the purpose as well as the pros and cons of each framework took place. At the end of the section, they were able to choose among the frameworks according to their purpose of assessment. For example, Hilal described each assessment framework in her reflection and she noted that

> "Among these frameworks, we cannot say one is better than the other framework. Here the important thing is what you are trying to measure and the aim of your lesson is. Getting used to different kinds of assessment frameworks for the argumentation of the students was very useful for us since we had chance to use them in our second lesson practice in the schools… In conclusion, these frameworks can be used to evaluate students arguments by using different activities prepared in different contexts. Also, depending on different purposes, new frameworks may be generated for the evaluation of arguments." (Hilal, RP-8, p.1, l.14-17)

In his reflection, Can followed a different presentation format. He applied one of the frameworks to evaluate the students' argumentation in his science class. Then, similar to Hilal, he stated that

> "Although there are great number of ways to evaluate students' argumentation, each of them may not be suitable every argumentation processes or products. Thus, teachers and researchers have to choose appropriate methods for evaluation of their students. For instance, if it is laboratory study or experiment, you had better chose Lawson (2003) pattern. If it is more associated with theoretical background or laws, Kelly and Takao's will be more useful analyses students' efforts." (Can, RP-6, p.1, l. 9-14)

In relation to their learning throughout the course, and particularly in section 6, the participants were asked to evaluate students' extended arguments in the post-interview

(see Appendix D, p.337). The case was the same with the one (two blocks with ice), which was provided in the pre-interview but the students' arguments were incorporated more data and justifications. The data for Can were corrupted for this question but Hilal, in contrast to the pre-interview, looked for *evidence* and particularly *experimental data* as a criterion in addition to evaluating students' arguments in terms of *students' understanding of a concept*;

> "I think that both of them are highly credible. First of all, both of them support their cases by an observation, which is measurement of the temperatures. The second student notices the difference in the initial temperatures of the blocks. Actually, their idea is the same but their statements are different; one says that A is a good conductor and the other says that A is a good absorber. Therefore, I think that both of them are highly credible and both of them have evidence." (Hilal, PI)

At the end of the course, the statement of argumentation assignments portrayed a completely different aspect of argumentation. As opposed to my expectations that the participants would think about the argumentation as a core process of science and would tend to shift their orientations to students-centred and constructivist approach to science learning, their statements were constrained in terms of definition, structure and the purpose of argumentation. For example, Hilal described *argumentation as a process*, but only focused the role of *argumentation for conceptual understanding*. Moreover, she was tended to see *teacher as* not only *the facilitator* but also *the centre of any communication*:

> "If someone will ask me what do you understand from the word argumentation and why is it important for the education of children, most probably I will give these answers; argumentation is a process of 1- teacher-student interaction in the classroom (asking and answering questions, encouraging, arousing curiosity, thinking deeply, etc.) and 2- generating arguments, counterarguments, and rebuttals about the topic that is discussing in the classroom. The second question, why argumentation is important may be answered in short; it enhances student understanding of science. …In addition, my other observation is that teacher is a key component of this process. If teacher I is not a good facilitator of the process, the generated arguments will be weak. Finally, in the argumentation process, teacher should have a strong content knowledge and s/he should be well prepared for the course." (Hilal, SoA-3, p.1, l. 4-11, 16-19)

Similarly, Can described *argumentation as a process* and *a teaching method*, and he only focused the role of *argumentation in learning science*:

> “Firstly; teaching practices are important because we gather information from student’s argumentation process directly. As a result of these teaching practices, I am convinced that argumentation is a suitable teaching method for all level of science education. …Secondly, Murat Günel and Halil Tümay‘s studies demonstrate importance of argumentation in science studies. Since, their projects focus on efficiency of argumentation in science, they shared result of their studies and own experiences. They explained about contribution of argumentation to learning of science.” (Can, SoA-3, p.1, l. 4-6, 11-14)

However, these statements were not their final perspectives; rather they were short accounts of their understanding. The participants described how their understanding of theory and pedagogy of argumentation change over the graduate course in their post-interviews. For example, Can defined *argumentation as “the gist of science*” in the post-interview. He further clarified the change in his understanding such that

> “Argumentation is a concept which is the gist of science. We introduced to the concept in the articles beginning from the first week and conceived its meaning in the following. In brief, my understanding or my viewpoint about argumentation is that it is the gist of science; it is a technique which conveys the gist of science not limited to scientific procedures and techniques or methods of science to the education environment. I mean that we transfer the science that scientists do to education environment, to classroom through argumentation. That is how I understand argumentation.” (Can, PI)

The definition made by Hilal was formulated in terms of the structure of argumentation, and there was referral to the *argumentation as a process* and *social interaction*;

> “I can say that argumentation is construction of arguments about a topic of discussion. What do I mean by ‘constructing arguments’? I mean that constructing an argument is to support a proposed idea and to refute the opponents. That is, in an argument, a proposed claim should be supported by clear evidence rather than being fallacious or ungrounded. Argumentation is this process. In addition, I remember that in an argumentation, there should be social interaction.” (Hilal, PI)

As regards to the role of argumentation in science education, Can’s perspective was situated in wider goals of science education; such that appreciation of diversity, intellectual wealth, and understanding the nature of science. For example, he stated that

> “Q: Why do you think counter-arguments should be included in argumentation?

Can: As educators, we all desire an inclusive classroom culture where diversity of the ideas will be the norm. First of all, students respect to other's ideas, accept the claim that there are no absolute truths, and appreciate of diversity of views and counter-arguments. Secondly, it is the natural process of science, let's say, in the nature of science. We always encounter diversity of ideas when we try to explain things. Therefore, we would like our students to be aware of this situation while teaching science. It is an intellectual wealth. Argumentation is in the nature of science and it makes the transfer possible by means of counter-arguments. As a result of all this, we can claim that students gain intellectual wealth, respect to other's ideas, and appreciate the diversity of views." (Can, PI)

At last, the participants were asked to construct arguments in the post-interview to investigate the development of their arguments at the end of the course. The question was similar to the one in the pre-interview, such that the participants were asked to use the evidence statements provided in support of their argument. The claim was that the day and night are caused by spinning Earth. The results demonstrated that Can incorporated more components of argumentation and particularly strong rebuttals as evaluated by Toulmin's Argument Pattern;

"As much as I remember, in astronomy, we know that day-and-night is the result of the Earth's rotation around its own axis while seasons are the result of the Earth's revolution around the Sun **(W)**. …When I think about the days in seasons, the day-time is different for winter and spring. However, the day-time can be different in random two days in winter **(R)**. …There is no relationship between the phases of the Moon and the day-and-night because the phases are related to the revolution of the Moon around the Earth, to how we see the Moon from the Earth **(R)**. …We can refer to a specific point where we can observe the other stars rotating around that point in a circular and counter-clockwise direction; we can infer that the Earth rotates around its own axis **(D)**. Therefore, a supports the claim that the Earth rotates around its own axis **(C)**. D is more related to the Moon's revolution around the Earth, c is more related to the Earth's revolution around the Sun, and b is more related to the Earth's revolution around the Sun as well as around its own axis **(R)**. In sum, a is a result of the Earth's rotation around its own axis **(C)**." (Can, PI)

The argument provided by Hilal incorporated more rebuttals as evaluated by Toulmin's Argument Pattern, however either they were weak or scientifically invalid;

> "The day-and-night as a result of the Earth's rotation around its own axis is related to the reflection of the Sun rays at different places during the rotation of the Earth **(C)**. …I don't think that seasonal transition times support this phenomenon because although I don't know why these transition times are different- maybe they are different because of the wavelengths or the heat coming from the Sun light, I cannot relate this directly to day-and-night **(R)**. …the rotation of the stars in a counter-clock wise direction indicates the rotation of the Earth. I mean that they look like rotating because the Earth rotates **(D)**. …In a similar way, the phases of the Moon might be related to the amount of light coming from the Sun to the Earth although it is not directly related to the Earth's rotation around the Sun **(R)**." (Hilal, PI)

Reflections and the refinement of the design solution

Upon the completion of the course, another meeting with my supervisor was held (J.C. -feedback, 25.05.2012-16:15, duration: 27.13 min.). The overall evaluation of the course and the revisions to be made for the refined design solution were discussed.

First of all, the participants could not have chance to use the Learning Design because of the technical problems associated with the online version of the Learning Design. The participants were introduced to other Learning Design platforms, but none of them were specifically designed for argumentation-based learning designs. For this reason, the participants could be able to experience the Learning Design platform on a CD, however, they couldn't access it all through the term. Thus, the online version of the Learning Design had to be ready at the beginning of the term, otherwise, it had to be removed from the course content. Later in the third meeting, because the testing of the Learning Design was not performed, eventually, it was removed (J.C.-feedback, 12.11.2012, duration: 27.39 min.)

Secondly, for the revisions to be made on the initial design solution, the participants' reflections and feedbacks on the course were crucial. Therefore, post-interview questions were reviewed to include questions asking for first, how the changes in the syllabus within the term were perceived by the participants, and second, which readings and activities were influential in their learning.

Another discussion was on the schools for practice. The practices were constructive opportunities for the participants. For example, regarding his practices in school, Can said that

"Q: I just made up this question. We usually read articles to learn the theoretical underpinnings of the argumentation, and we aimed that you have a meta-level understanding of argumentation. Thus, you had to read articles and you tried to transfer what you had learnt into practice. How much do these two compatible with each other?

Can: Theory and practice?

Q: Yes, I mean that to what extent your theoretical knowledge about argumentation was reflected in your practice?

Can: The practices were the reflections of the theoretical knowledge we gained in this course. I did not experience anything extreme or unexpected. My experiences were usual complications in a classroom such as the nature of the topic, culture of the class or teacher. I mean that they were usual for a classroom, nothing was extraordinary. I can say that if we leave these usual circumstances aside, the procedure of argumentation given theoretically is embodied in actual practice. My observations regarding the feedback provided by students demonstrated that students could think argumentatively in relation to the process, and took part in the activities accordingly." (Can, PI)

On the other hand, the practices were not without struggles even if the students were familiar to argumentation. For example, Hilal stated that

"Q. What do you think about the applicability or transferability of what we have learnt in the course into the practice in classrooms? Did you experience any problems or did you need to develop your own strategies?

Hilal: …I did not have a hard time implementing argumentation in this class since the students were familiar but still the arguments were naïve. Therefore, I don't think that argumentation is a great way to teach science in Turkish context.

Q: Well, as much as I understand, you don't think that argumentation theory is applicable or transferable into the practice?

Hilal: No, I don't. On the contrary, I think that argumentation can be implemented but students should be prepared to practice argumentation and teacher should know the theory of argumentation, the levels and the steps of argumentation, and be familiar to practice of argumentation as a process. I don't say that argumentation is impossible but I say that there are pre-requisites such as the

> readiness of students and the teacher. …I might only say that we could talk more on our practice videos." (Hilal, PI)

In addition, the possibility to practice were also few to master argumentation. For example, Can said that

> "Q: What would be your suggestions for the next term?
>
> Can: …The classroom management was already hard for the teacher and harder for us since we know students less. That was just the second time we see the students and we were like strangers so we had harder time in classroom management." (Can, PI)

Moreover, all of the participants were not employed teachers. Some of the participants were graduate students, who were graduated from teaching programs and were studying for a master's or doctorate degree. They were going to be teacher educators in the future. Therefore, in our meeting with the thesis monitoring committee members (TMC. - feedback, 06.06.2012, duration: 37.42 min.), these participants' learning was of interest in the sense of their purpose of learning and responsibility attached to their roles as teacher educators and their expectations. Therefore, I needed to think about education of teacher educators as well and made some adjustments in the initial design solution. In so doing, as Loughran (2014) suggested, I decided to share my teaching and learning experiences of teacher education practices; that is teaching about teaching, with "a serious focus on pedagogy, conceptualizing teaching as being problematic, making the tacit nature of practice explicit, developing a shared language of teaching and learning, and the ability to articulate principles of practice" (p. 5). Moreover, in support of their learning about teaching (Loughran J. , 2014), I decided to model argumentation as a teaching method in all our discussions for the refined design solution so that their learning was enhanced by the knowledge and practices by which they come to learn from.

Additionally, teacher educators had to find schools to practice argumentation in a real science classroom. However, they had difficulty in locating schools available for practice. Therefore, another suggestion was to contact with available schools beforehand to assign the participants for their practice. Some of the administrators in schools, for example, the one Can went to for practicing argumentation, was helpful and eager to accept other teachers. Thus, I contacted with them for the next term.

As regards to the content of the course, in the meeting held with participant observer, who was a graduate student and participating in most of the course, about the progress from the perspective of the participants and to what extent the research was on target, she was in the opinion that the discussion questions were helpful to elucidate the points that the participants did not clear about. She suggested having alternative discussion questions in order to orient the discussion around the main points that need to be emphasized (K.B. - feedback, 16.03.2012-14:23, duration: 02.56 min.). I was in agreement so I selected questions from the list of the participants' questions and also I prepared supplementary discussion questions for the rest of the classes.

However, as Can stated in the post-interview, after a few weeks, the classes turned to be a routine discussion and activity sessions without any innovation.

> "Q: In your opinion, which aspects of the argumentation were effectively addressed in the course?
>
> Can: What do you mean by aspects of argumentation? In the course, you mean?
>
> Q: Yes, I mean that which topics did you remember? Which topics did you learn well?
>
> Can: To be honest, the articles in the first weeks were a little boring. They were more about the philosophy aspect of the argumentation and were using scientific language. They were a little bit difficult and boring. Later we learned the practical side of the subject like what a rebuttal is, how arguments are constructed, which argumentation frameworks exist etc. Since then, the course was more fun because we were engaged in argumentation and liked that. That technical part was good. Argumentation about socio-scientific issues was good." (Can, PI)

The unvarying progress throughout the course was also the concern in the meeting with my supervisor. Thus, we identified the classes and activities, which were more intriguing for the participants and the ones, which were less attractive or not productive. For example, the class for section 5, which was about the argumentation in socio-scientific contexts, was unusual for the participants because of several reasons. One was the subject of the class. The subject was a local issue, which all participants were familiar to, and were attentive because they all had a word to say about the subject. Another reason was that argumentation embodied not only scientific data but also personal values, viewpoints, political, moral and ethical decision-making. Up to section 5, the focus was on the scientific argumentation but in section 5, they were faced with an unfamiliar argumentation process, which awakened their interest. On the contrary, section 6, which was related to assessment frameworks, was difficult to synthesize for the participants. For example, Can stated that;

> "Q: Yes, I mean that which topics did you remember? Which topics did you learn well?
>
> Can: …I think that the class about the evaluation of argumentation was less effective for me. There were lots of techniques and methods to evaluate argument but I hardly recall them. What should I take into account while planning an argumentation lesson or argumentation-based activity? There was a schema that shows what is important in argumentation. I don't know if it could be more specific from the perspective of a teacher such that 'this one can be graded lower and this one higher because of this', just like that, just an idea." (Can, PI)

Therefore, the refinements made comprised the revisions on the activities.

Another concern regarding the content of the course was the compatibility of the readings with the participants' learning needs and the activities. For example, in the syllabus, as in the planned tasks for the course (see Appendix C, p.326), there were optional readings, which were also referred to as the class discussion proceed. However, most of the time, the participants were not ready for a reference to optional readings. Besides, the guest speakers did not always addressed the topic of the week fully. In other words, the presentations were related to argumentation and they were helpful for the participants to understand different contexts in argumentation, however, they did not always tie with the topic of discussion. For example, section three was supposed to address written argumentation frameworks, however, the discussion with the guest speaker focused on the practices of teachers in schools, which were more appealing for and wanted by the participants. Hilal pointed out to this section in the post-interview;

> "Q: In the course, do you think that you have learnt the argumentation effectively? Which aspects of argumentation were discussed well than the others or did you learn well?
>
> Hilal: I remember the Toulmin's model and three other models. We discussed all their patterns clearly. I have learned how to implement argumentation effectively in classroom. We talked about the socio-scientific argumentation. I have not learned much about the written argumentation I guess." (Hilal, PI)

In a similar vein, the videos or the activities were not always effective. For example, some of the videos derived from the resources of other frameworks were not easy to follow or understand. The participant observer pointed out this issue in our meeting;

> "To be honest, I am not sure to what extent the videos were clear to the participants, because I did not understand what the first two videos were related

> to. Well, there were videos but I expected a discourse between teacher and students. There were students arguing on a subject, which is good in a way but what was the purpose? Why did we watch these videos? On the other hand, the third video was really helpful because there were labels in the video to clarify what the video was about. Therefore, I suggest you to make brief explanations regarding the purpose of the video or the content of it." (K.B. - feedback, 16.03.2012-14:23, duration: 02.56 min.).

For this reason, revisions were also made considering the compatibility of the activities, including videos, and readings with the learning needs of the participants.

Summary

In the evaluation, I empirically tested the initial design solution and investigated the operative as well as inadequate aspects of it. Moreover, I tracked the changes in the participants' theoretical understanding of argumentation in science teaching and learning. In my investigation, I used the participants' reflection papers, statement of argumentation assignments, course audio-records, post-interviews, and meetings with my supervisor and participant observer as data sources. I used interpretive phenomenological analysis to explore the meanings different stakeholders assigned to their experiences in the process.

The results related to the initial design solution can be summarized as;

- The initial design solution contributed to the participants' knowledge related to argumentation in terms of their understanding of argumentation theory and process as evidenced in their reflection papers, statements of argumentation, and post-interview data.
- The content of the graduate course were presented as combination of theoretical background and associated activities. The presentation and the content of the course were effective in the sense of achieving the objectives of the course as evidenced in the reflection papers of the participants. However, there were instances that the content, organization or the structure of the course needs to be changed.
- The participants' understanding of argumentation improved over the graduate course as evidenced in their statement of argumentation and post-interview data. However, this understanding was not always resulted with valid arguments as shown in the post-interview data. On the other hand, the low-quality in terms of scientific correctness could be linked to the participant's lack of conceptual knowledge on the subject, rather than her understanding of argumentation or her ability to construct high-quality arguments.

Based on the results of this investigation, given above, I refined the initial design solution to improve it and constructed another design solution, which was further tested in the next term.

3.4.3. The evaluation of the refined design solution

The initial design solution was empirically tested in the spring term of 2011-2012 academic calendar. During the summer term, the revisions were made based on the abovementioned results of the first testing. The revisions made resulted with a refined design solution, which was empirically tested in the fall term of 2012-2013 academic calendar.

The refined design solution was also supported with the integration of tasks, such as readings or articles to be discussed, pre-activity discussions, activities, and post-activity discussions, as well as resources like videos, presentations, worksheets, lesson plans, analytical frameworks, and sample excerpts from students' argumentation derived from the literature (see Appendix E. Syllabus, p.339).

3.4.4. Results

Five of the participants, Asya, Seher, Mahmut, Birhan and Mesut were enrolled in the second term of the course and experienced the refined design solution. The results covered their description of experiences written on their statements of argumentation in three instances of the course (beginning-middle-end), reflection papers per week and post-interviews, as well as meetings with the supervisor and the participant observer, and audio records of the course.

Section 1. Introduction to argumentation

The introduction to argumentation in this second term did not begin with a discussion on communication and persuasion because the participants were already familiar to some of the discourse processes (see Pre-interviews to explore participants' understanding of the problem, p.114). Therefore, the course was initiated with introduction to argumentation. However, as different from the previous term, the participants in this term were more interested with the philosophy of science and argumentation, in particular. Most of the participants were not familiar to the differences between positivist- post positivist, interpretive, and constructivist approaches to science learning. Therefore, the discussion was focused on the philosophical orientation associated with the argumentation mainly. Another reason was that Mesut, who was one of the participants, was acknowledged about argumentation and was keen to discuss the philosophical underpinnings of argumentation. His knowledge and approach enticed the other participants. Therefore, in order to create a discussion platform, stressing the need to build up a common understanding and to be on the same target, the philosophy of argumentation was given priority.

The construction of knowledge about the epistemology of science was challenging for most of the participants. For example, Asya wrote in her reflection paper that

> "I, as a teacher, do not know how to teach this epistemology of science to my students. In addition, I did not totally understand what makes a scientific claim a law or a theory. Therefore, I needed to search a little bit about the definition of law and theory once again and found out that there are different types of laws, like an exact law and approximate law." (Asya, RP-1, p.1, l. 13-17)

Mahmut, alternatively, constructed a link between post-modernism and argumentation;

> "Actually, post modernism serves to argumentation. Post modernism presents us dilemmatic or controversial issues. That requires discussion and persuading others. In this point, argumentation takes central role. There is a dilemmatic and discursive environment in the nature of argumentation." (Mahmut, RP-1, p. 2, l. 39-42)

The purported coherence between postmodernism and argumentation suggested by Mahmut was not discussed in the course. Considering that all participants were graduate students, they already had understanding of certain philosophical orientations. Therefore, it is usual that they connected the discussions about argumentation and logic in the first lesson to their earlier conceptions and philosophies. On the other hand, these initial connections between argumentation and other philosophies- although I cannot claim that they were right or wrong- has a shallow basis because we just had an introduction to argumentation from different perspectives and we did not engage yet in deep discussions regarding the approaches to argumentation from different philosophical orientations. These initial connections made by the participants were addressed at different instances of the course.

The reading in this section addressed the difference between logic and argumentation (Driver, Newton, & Osborne, 2000), which was also thought-provoking for most of the participants. For example, Asya stated that

> "The definitions of the deductive and inductive reasoning were not very clear to me when we had the discussion about these two reasoning. Thus, I had to do a little bit of research on these two. Deduction was confirmation of the re-stated

> theories, whereas induction was producing theories or generalizations based on the evidence” (Asya, RP-1, p.1, l. 21-24)

Similarly, Seher wrote that

> “This week I’ve learned that, argumentation is a human practice that is satisfied through social interaction between groups or individuals by thinking, speaking and writing. It is a human practice or individual activity in social settings and it is contextualized. By this property, it is apart from logic as logic can be stated as decontextualized. Both argumentation and logic forms conclusions from premises, however they differ in their ways. Logic has certain rules to come up with conclusions whereas argumentation does not offer any.” (Seher, RP-1, p.1, l. 2-7)

Overall, the aim of this section was to provide an understanding of argumentation along with its main features and the role in science education. Considering that most of the participants had either no idea or very naïve ideas about what an argumentation is, at the end, I can argue that the participants achieved such understanding. For example, Birhan had not have an idea about argumentation as she wrote in her first statement of argumentation assignment. However, at the end of this section, she wrote that

> “First of all, argumentation is the social contact of the claims and it should be accepted heart of science education, because its nature is very strictly integrated with the epistemology of science and nature of science. In argumentation students should be listened and we should let them explain their claims with their evidence, everyday experiences, and background knowledge. …In general science teaching composes of four dynamics, science knowledge, integration of science in technology and society, establishing science process skills and going through science nature. Argumentation is applicable for these four dynamics separately. It is not related some of them but all of them.” (Birhan, RP-1, p.1, l. 7-10, 20-23)

Similarly, Seher referred *argumentation as “sharing, comparing and contrasting different perspectives*” (Seher, SoA-1, p.1, l. 2) in her statement of argumentation. However, she extended her definition as well as her understanding of the role of argumentation to a more comprehensive perspective at the end of the section;

> “To conclude, argumentation in science literature is a need for developing conceptual understanding, investigational capability, and understanding of scientific epistemology, critical thinking ability and social contributions. If students can see science as a way of social practice and a must in their life wanting to be in the science, they should learn about the progress of science from theories

coming from past. In addition they should be aware of that progress will continue." (Seher, RP-1, p.2, l. 40-44)

Section 2. Strategies for defining and supporting argumentation

Section 2 was implemented in two weeks (6 hours in total).In the first week, we went through two different resources about the framing for scientific argumentation. Firstly and mainly the reading was discussed with the participants and then the strategies for promoting argumentation were evaluated. In the second week, a research article, which exemplified how to support students' argumentation, was discussed and the process was modelled by an activity. The participants were particularly attentive to the activity. For example, Seher wrote in her reflection paper that

> "In the other part of the lesson we saw examples of creating argumentation in class. We tried to find evidence and justification for claims and took part in argumentation process in burning candle experiment. Being a student in this process helped me see the point of view of the students. I concluded that, the directions should be understandable, working as a group is helpful, sufficient time should be given to the students, interesting (engaging) and challenging tasks should be used. I also realized that the teacher should be prepared very well on the subject as the students can have very different opinions on the subject" (Seher, RP-3, p.2, l. 47-49)

Similarly, Birhan stated that

> "We also perform an experiment; and through the given information and our observation; we conduct our evidence and justifications. But in that experiment; we only try to clear and deepen our understandings, we never try to "win" or get a credit from the teacher. However we compare our behaviour with the students' behaviour." (Birhan, RP-3, p.2, l. 42-45)

Additionally, because the participants were asked to plan and practice an argumentation-based lesson in a classroom for the next classes, they requested examples of such a practice. For this purpose, the video-recorded practice sessions of the previous term were provided to the participants. This activity was helpful to clarify what they were expected to do as teachers in an argumentation-based science lesson. Regarding these examples, Asya wrote that

> "In some part of the class, we saw some video examples of the argumentations conducted by the students in last semester. It gave us really good ideas about how to conduct the argumentation in class. I learned that I should start with idea

chasing to engage the students in class. I can also use concept cartoons having a conflicting issue. The most important thing in the argumentation is that the argumentation must create counterarguments and we can make this happen by using evidence cards. We can also ask students to give their justification about why the evidence cards that they use or do not use in supporting their argument supports or do not support their argument. In this way, the counter-arguments could be created and students could be aware of their evidence while conducting the argument. We have to keep in our mind that the most important thing while conducting the argumentation is that students have to make decisions and use higher order thinking skills. This could be done through rebuttals and counter-arguments." (Asya, RP-3, p.2-3, l. 43-54)

The main objective of this section was to enable the participants to synthesize various pedagogical strategies and ways in order to support students in identifying, understanding and using evidence in argumentation. At the end of the section, the participants were able to design a lesson plan and resources that consist of argumentation by utilising several strategies introduced in the section (see chapter 4).

Section 3. Written argumentation

In section 3, Science Writing Heuristic (SWH) approach was introduced and a guest speaker, Kutlu Tanriverdi, was invited to present examples of teachers' practices using SWH. K. Tanriverdi was a research assistant, who was involved in a number of national and international projects targeting the teaching of argumentation through SWH (Günel & Tanrıverdi, 2012; Tanriverdi, Demirbag, & Gunel, 2011). He engaged the participants in an argumentation activity using SWH first, and then he showed videos of teachers' practices. The activity and the videos were intriguing for the participants. To illustrate, regarding the activity, which was about the buoyancy force, Mesut wrote that

"Even though we could not reach a satisfactory conclusion regarding what buoyancy really is, we examine many of different conceptualizations which are possible related the term of buoyancy anyway and we fired and also triggered our both working memory and long term memory, and after disequilibrium, we have a more rational and scientific schemata and equilibrium regarding buoyancy." (Mesut, RP-4, p.2, l. 43-48)

In a similar vein, Mahmut stated that

"We had an experiment about buoyancy of water that causes an object to go up in a medium. In this experiment, we sought the possible explanations of why a lemon is hanging in the water. Of course the reason was buoyancy of water, however we did deep research and thought why there is buoyancy. Without experiment, all of us can explain the buoyancy of water but SWH provided us to approach from different perspectives. …Until now, all I mentioned showed that we did good argumentation in this process because we tried to defend our argumentation, we produced counterargument to each argument and we developed different views and indicated limitations of our views." (Mahmut, RP-4, p. 1, l. 4-8, 11-14)

Asya also expressed her experience with the activities such that

> "It was an interesting class this week. …As a result of the discussion that we had in the class this week and also reading the articles on SWH, I learned that SWH is a very important tool to conduct an argumentation in class since it makes the students own the research question, conduct the necessary experiments, collect the relevant data, and make conclusions based on the data and argue what he / she found as a conclusion in class. Here, the students are making decisions and using their critical thinking skills. Therefore, it is a very important tool in students' critical thinking skills and conceptual understanding of the subject matter…I am really amazed with the studies that the guest speaker was part of and overall, I enjoyed the class a lot this week." (Asya, RP-4, p.1-2, l. 32-42, 72-74)

The video records shown by the guest speaker were helpful for teachers also to overcome the presuppositions related to the implementation of argumentation in science classrooms. For example, Seher wrote that

> "The project mentioned by our guest was very interesting and I believe will have a good influence on science teaching in schools. Even the project is done by 6th, 7th and 8th graders (and now 5th because of the changes in our education system), I believe that, the project can be done also for high school and this will be a great step for the use of argumentation in our curriculum. Like all other teachers, I was afraid of the time needed for using argumentation as we have to follow a strict curriculum and don't have much free time, he explained that, only the first year it took a long time. After getting used to the strategy, it takes less time and so it's easier to conduct argumentation in science teaching." (Seher, RP-4, p.1-2, l. 35-41)

The reflections of the participants were shown that the participants, especially who were teachers, were ready to use the argumentation strategies acquired in the sections. For example, Birhan wrote in her reflection paper that

> “This week we learnt another type of expressing the argumentation in science classes. In this type, I understand that students’ some other skills can be also improved. … In proceeding semesters, I want to apply SWH techniques because it enhances students’ high level of understanding, improving their writing skills.” (Birhan, RP-4, p.1-2, l. 5-6, 36-37)

At the end of this section, the statement of argumentation assignments submitted by the participants demonstrated that the participants developed a new perspective about argumentation. For example, Asya had a view of argumentation at the beginning of the term as *argumentation as a teaching method* and *argumentation as supported claims/ connecting data with claims* (Asya, SoA-1, p.1, l. 1-2). In her second statement of argumentation, the description of argumentation made by Asya was more comprehensive because she also included *the contribution of argumentation to higher-order thinking skills* and *understanding of nature of science* as well as *the importance of alternative views*, *counter-arguments*, and *rebuttals*;

> “In my first statement, I defined argumentation as ‘making supported claims in a respectful atmosphere.’ I still think about the argumentation in the same way, but with some additions to that definition now. The claim has to involve rebuttals as well to make the argument stronger. However, it is not easy to provide the rebuttals in an argumentation and it definitely requires the students use higher order thinking skills. The nature of the subject to be argued should be able to provide counter-arguments. …With the presence of counter-arguments, students get flexibility with themselves and understand that the nature of science is open to change.” (Asya, SoA-2, p.1, l. 32-37, 39-40)

Likewise, Seher also focused on the role of argumentation in promoting *higher-order thinking/ critical thinking*, *conceptual understanding*, and *for learning science/ nature of science* along with the *social constructivist framework;*

> “By argumentation the students can learn themselves, and this knowledge will be more permanent. …they actually learn the knowledge, they can use it in their daily life. In other words argumentation enhances higher order thinking abilities. …It is also appropriate for the nature of science. As there is no direct one answer. It is flexible. Social construction is achieved. Doing science is achieved.” (Seher, SoA-2, p.1, l. 21-27)

Birhan also referred to the argumentation *as supported claims/ connecting data with claims* and she emphasized the role of argumentation in promoting *higher-order thinking/ critical thinking* and *conceptual understanding* in her second statement of argumentation assignment; whereas Mahmut and Mesut concentrated on the role of *argumentation for learning science/ nature of science*.

Section 4. Practical inquiry and argumentation

Section 4 was implemented in two weeks. In the first week, for the refined design solution, I planned a complete argument-driven inquiry, because the participants, who were enrolled in the initial design solution, provided positive feedback about the first-hand experiences they had. In this section, the participants experienced all steps of argument-driven inquiry in the laboratory (Figure 2).

Figure 2 The participants experimenting in argument-driven inquiry session

However, the participants' reflections were not as anticipated. In other words, the participants did not reflect on their experiences but rather they focused on describing their understanding of the argument-driven inquiry framework. Moreover, although most of the participants wrote about the advantages of the framework, one of the participants, Seher, stated that the process was too complex to implement in science classes;

> “As a teacher I didn't like this method and wouldn't want to perform in my class. It is so complex, time consuming and uncontrollable. The students may not be aware of the hints given in the handouts and may do everything wrong; they can come up with nothing and disappointed. Some students would like to do things in an easy way, leave the work to their group members or do very simple, unnecessary or dangerous experiments. Or some students would work so much to do everything right. It is hard to determine those things and the hard worker student can be disappointed in the end when they are not appreciated.” (Seher, RP-6, p.2, l. 48-54)

The results regarding this section showed that not all participants favoured the argument-driven inquiry framework because it took 3 hours to conduct the experiment and reach a conclusion for the participants. Additionally, based on the statements by Seher, I draw the conclusion that some of the participants had concerns regarding classroom management and students’ learning during argumentation. This conclusion is in consensus with the research by Simon, Erduran and Osborne (2006) stating that “During the early workshops teachers expressed anxiety about presenting alternative theories to students (i.e., competing explanations for how we see objects) as they thought these may cause confusion for students and strengthen their belief in scientifically incorrect ideas” (p.255). The problem was addressed in the subsequent class.

Additionally, in the next class, I also extended the discussion about the philosophy of science, because the participants requested more information in order to be more involved in the discussions. For example, Asya stated in her reflection paper that;

> “As the final discussion point in class, we talked about paradigm shifts but I did not really understand about it much. I especially want to know more about epistemic shift and paradigm shift. I am happy that we are going to discuss more about these two next week in our class.” (Asya, RP-6, p.3, l. 63-65)

In the second week, taking the participants’ concerns into account, first, I initiated the discussions on Kuhn’s paradigm shift (Kuhn, 1970) and Lakatos research program (Lakatos, 1978). These philosophers were chosen on purpose because these were the ones addressed frequently in the previous lesson by Mesut by their ideas related to how scientific knowledge develops or evolves in science. Thus, the interest was mainly concentrated on their perspectives of scientific knowledge. The session was mostly informative but not discursive because most of the participants encountered with the subject for the first time. For example, Asya wrote that

> “In our class this week, we started discussing about Kuhnian paradigm and Lakatos’ research program. This was quite new for me. I have never heard about Kuhnian paradigm and Lakatos’ research program before. It was, at the beginning, hard for me to understand in the class too. However, I believe that things were clear about Kuhnian paradigm and Lakatos’ research program at the end of the discussion about these two in class this week.” (Asya, RP-7, p.1, l. 5-9)

Secondly, the research article about teachers’ roles in inquiry and argumentative learning environments, and how teachers support particular students’ roles and practices, focuses on inquiry and argumentation were evaluated. The participants had already reflected on their first teaching practice, therefore, the discussion was an opportunity to identify the common problems in argumentation practices. For example, Mahmut wrote in his reflection paper that

> “I compared teachers’ views and my ideas about these barriers. It is interesting that most of the problems that teachers mentioned are similar to my problems in class.” (Mahmut, RP-7, p.2, l. 43-45)

Similarly, Seher realized that she had similar problems reported in the literature;

> “The other barrier was time management. As a teacher, I have that barrier too. But I believe that, the underlying reason for this is the curriculum.” (Seher, RP-7, p.1, l. 21-23)

Section 5. Argumentation in SSI contexts

The experiences in the previous term with the initial design solution revealed that a local socio-scientific issue, which was on the agenda of the people, was intriguing for the participants and incorporated more participants into argumentation. Alternatively, for this section, we picked a general issue of the use of biodegradable bags. As in the initial design solution, argumentation on socio-scientific issues reinvigorated the participants’ attention and dissolved the repetitive organization of the classes. Mahmut pointed out this issue in his reflection paper;

> “Until now, we discussed the issues related with science that are not directly infused with society, environment, economy, policy, technology. However, we used argumentation strategy constructing claims, justifications, warrants, and rebuttals. Similarly, in this week we suggest our claims, arguments and counter

arguments and we tried to persuade each other about biodegradable bags use whether we should use them or we should not because of its possible harms. During this process, we made informal reasoning that describe the generating and taking position towards a socio-scientific issue." (Mahmut, RP-8, p. 1, l. 5-11)

The objectives of the section were to enable the participants to explore how argumentation and discourse could be used in the context of science-technology-society or socio-scientific issues, and to recognize the social interaction in argumentation. All participants addressed these objectives in their reflection papers in detail. Moreover, the participants synthesized the discussions on nature of science with SSI. For example, Asya wrote in her reflection paper that

> "The characteristics of SSI are that they are ill-structured and have a connection with the scientific knowledge. When Nature of Science versus SSI is considered in the class discussion, we ended up that both have an interpretative side, no definite answer, and are socially constructed." (Asya, RP-8, p. 1, l. 21-24)

Similarly, Mesut explained in his reflection paper that

> "Secondly, socio-scientific argumentation ties with some aspects of NOS such as empirically scientific investigation and revelation, tentativeness of scientific knowledge and science as a social activity. To justify, both in terms of socio-scientific argumentation and NOS aspects evidences have importance in order to justify one's claim and individual uses evidence based arguments to coordinate knowledge claims with available data." (Mesut, RP-7, p. 3, l. 69-73)

Section 6. Strategies for defining and supporting argumentation

In the refined design solution, section 6, exploring assessment related to argumentation was planned and implemented based on the ideas presented by the framework Assessment and Practical Inquiry in Scientific Argumentation (APISA) (Erduran, Yee, & Ingram, 2011) (see APISA, p.156). The participants were presented assessment frameworks derived from the literature and asked to identify their own criteria for assessing students' argumentation.

At the end of the section, they were able to choose among the frameworks according to their purpose of assessment and they were able to create an assessment framework, which was likely to be a synthesis of other frameworks. For example, Seher explained her selection of specific frameworks in her reflection paper such that

> "In the class we preferred to combine Zohar and Nemet's framework with Schwarz to see both the structure and content and use easily as in class we would be assessing many student and a complex framework will take too much time. Combining Toulmin instead of Schwarz would also be good determining the components seemed to be hard to do." (Seher, RP-8, p. 2, l. 43-46)

Nonetheless, the section was challenging for most of the participants. Asya, for example, noted that she needed more practice in the assessment of argumentation;

> "In the second part of the class this week, we discussed about the assessment criteria which we produced during a class activity. Since we, as a group, found Toulmin's model familiar, the components that we produced to assess an argumentation were quite near his model. Our model included "correctness, evidence, data/observation, claim, and rebuttals" as the components of the argumentation that is to be assessed by us. The class this week was the first class on assessment of argumentation. It was very helpful to have some idea about the assessment frameworks. However, I, personally, need more practice on assessment in argumentation." (Asya, RP-9, p. 2, l. 33-40)

Though, in the evaluation she made in the post-interview, she successfully employed the same criteria that they considered in their framework. In other words, she evaluated the students' arguments based on *the availability of evidence*, *data/ observation*, and *justification* as well as *the scientific correctness*;

> "…the first student said that- that is what makes me stop and think- s/he said that it gives more energy in his/her first sentence but then s/he talks about a being a better conductor and talks about the speed. I mean that here, there are two things: one is that s/he talks about more energy without any support, and two is that s/he talks about being a good conductor based on the speed of the melting on block A. S/he supports the second with data. I think that the connection between melting faster and being a good conductor is missing. At least, the second student holds on one idea but still I hardly say that yes, this is the answer." (Asya, PI)

Likewise, the other participants used the same criteria, which were *the availability of evidence*, and *data/ observation* as well as *the scientific correctness*; however, *the quality of justification* as well as *the presence of the rebuttals* or *plural accounts* were not always in their agenda. Mesut indicated that the reason for not considering all components of an argument given in Toulmin's argument pattern was that

> “The knowledge claims proposed are scientific. That is, scientific argumentation takes place. I believe that if it was a socio-scientific argumentation, instead of looking for scientific correctness, I could investigate the quality and quantity of the components of an argument as instructed by Toulmin. Yet, it is a scientific argumentation, so I think that students’ scientific understanding of concepts and their rationalization from a scientific perspective are more important than the quality and quantity of the components of an argument.” (Mesut, PI)

Apart from their evaluations, in the results, there was an evidence of high level of understanding of argumentation achieved during the course as reflected in the participants’ statement of argumentation assignments. For example, in her last statement of argumentation, Asya emphasized *the importance of evidence*, *plural accounts/ alternative views/ dilemma*, *the importance of justification*, and *Toulmin’s argument pattern* from the perspective of a teacher;

> “As we are getting closer to the end of the semester, in my opinion, argumentation is a class discussion in which students provide claims based on evidences and with correct justifications. When students give their claims, they should also be aware about the limitations of their claims. Argumentation makes the students be flexible against others’ views since students get to hear counter-arguments or alternative views to what their claim is. Argumentations could be verbal or written. Argumentation also brings the view for the students that the nature of science is open to change.” (Asya, SoA-3, p.1, l. 11-17)

Upon the completion of the course, another concern was the participants’ ability to construct arguments. However, most of the participants put forward that the claim provided in the post-interview was not in their interest. As a result, their arguments were usually low in quality and scientific correctness because they were lack of the scientific knowledge to argue for or against each statement provided as evidence in the alternatives. Mahmut, for example, asked for another claim to support, preferably in biology, because he was good at biology. Only Mesut provided a high level of argument in his response to the question with several justifications and rebuttals.

Reflections

Based on the results of the investigation above as well as the post-interviews with the participants, and meetings with my supervisor and participant observer, I reflected upon the refined design solution with suggestions to improve it.

As indicated in section 1, the diverse background of the participants created the need to build up a common understanding and to be on the same target. Therefore, the discussion was focused on the philosophical orientation associated with the argumentation mainly. However, the gap was larger than I thought. Some of the participants had never been encountered with any philosophical thought regarding science or science education. For these participants, to follow the ideas presented in the readings or in the course was difficult. Therefore, they requested another session for the discussion of main philosophical thoughts regarding the construction of scientific knowledge. The change made in the design to address the philosophical thoughts shifted the program content and structure. In other words, the number of practical activities reduced significantly in the program. This shift led the course be too much theory-oriented rather than a blend of theory and practice. The over-focus on theory was also addressed by the participants. For example, Seher responded to the related questions such that

> "Q: Do you want to add anything? You may have suggestions or you may say that it would be better if we could do this instead of that or you may say that I need to learn more about this aspect. I mean that is there anything you want to add?
>
> Seher: I will suggest two things: first, the practices and the examples in the course are more effective than the theory of argumentation so the theory part might be less. I think that practices help us to gain confidence in implementation since by examples, which either we did as students or as teachers in classroom, our experience on the practice increases. Second, as students, we forget to take notes in the course or we don't understand our notes later. Maybe, a one or two page summary that includes the key points such as this is rebuttal and this is counter-argument, or the basics of argumentation might be provided or requested as an end-term project." (Seher, PI)

After the first four weeks of the implementation, we held a meeting with my supervisor (J.C.-feedback, 12.11.2012, duration: 27.39 min.) to audit the progress. In this meeting as well as in the meeting held with the participant observer (K.B. - feedback, 28.11.2012, duration: 31.49 min.), the issue, which was the too much emphasis put on the philosophy of science, was on the table. For example, my supervisor pointed out that

> "We ask them to prepare and implement argumentation-based lessons but we did a few classes with practice. The classes are too much theory-oriented. As you might realize, the participants only talk about the first activity they were engaged in because they do not have any other experience. For example, they did not recall the strategies they have seen in Tümay's dissertation. There should be

> more activities in order them to talk more about or reflect on their experiences. Well, they are graduate students but they are teachers at the same time. Therefore, you need to emphasize 'how to teach' aspect" (J.C.-feedback, 12.11.2012, duration: 27.39 min.)

Seher drew attention to this feature of the course in the post-interview;

> "Q: Does a teacher need to know the theory of argumentation to implement a productive argumentation lesson?
>
> Seher: …Such an intensive course work is too much for a school teacher because they lose their interest on subject when there are too many things to learn. We did not lose as PhD candidates but if I was just a school teacher and the course was provided as an in-service training, I could lose my interest, or I could only remember the most useful or meaningful ones." (Seher, PI)

Another issue, which was closely related with the first one, was that although the readings were informative, they did not always fully address the objectives of the section. For example, for section 2, the assigned reading reported an empirical research on students' understanding of nature of science and its relation to argumentation. However, because most of the participants' were not familiar to the views regarding nature of science, and some of them have never heard nature of science, the focus of the section shifted to the discussion to have a common understanding of the terms associated, such as nature of science and epistemology. This shift was one of the concerns addressed by the participant observer;

> "The discussion on the subjects such as nature of science or the philosophy of science put too much demand on you. You need to be prepared for discussion about diverse issues such as history of science, philosophy of science and science education, epistemology of science, etc. My concern is that the long discussions on these subjects make you divert from your objectives. Besides, you need to think about whether the participants' perceptions or understanding of these subjects are the same as yours, or are you an expert on these subjects to open them to discussion in an argumentation class. These discussions are too high-level. The question is that are these really necessary for learning and teaching argumentation" (K.B. - feedback, 28.11.2012, duration: 31.49 min.).

Similarly, Birhan asserted that

> “The theory part is the least catchy. …I don’t think that a teacher needs so much theoretical background since argumentation is an everyday practice, which works if teacher knows other activity-based science teaching tasks.” (Birhan, PI)

With regards to these two issues, which were the reduced number of activities to experience argumentation and the incompatibility of the readings with the objectives of the sections, I made some revisions in the design solution. First of all, I replaced the readings by those provided in the first term and was more productive in addressing the objectives of the class. Second, I immediately incorporated activities for the subsequent sections in relation to the readings with the purpose of engaging the participants in argumentation practices as learners and teachers. For example, following the suggestions of my supervisor, I incorporated peer evaluation of the videos of the participants’ teaching practices. These changes made a difference for the participants. For example, in the post-interview, Birhan specified that

> “Two things were remarkable for me in the course: evaluating our friends’ implementation of argumentation and the videos on the real teachers’ experiences displayed by the guest teacher. The teachings in the laboratory, the presentation of that practice, and the candle experiment we did were promoting long-term learning. This learning is long-term since we did something else rather than reading only.” (Birhan, PI)

Nevertheless, some other revisions made on the initial design solution did not resulted with the successful attainment of the objectives. For example, a comparison between the participants’ reflections, who experienced the initial design solution and those, who experienced the refined design solution demonstrated that in section 5, definitely local issues were more productive to help the participants discover the characteristics of the socio-scientific issues.

Despite the abovementioned concerns, the design solution offered a new perspective for the teachers enrolled in their teaching and career. For example, Asya indicated that the course assisted her in evaluation of the students’ work from a new perspective;

> “I have learned a lot. For example, my students often engage in argument-driven inquiry, especially while writing laboratory reports. There is conclusion- evaluation part of the report and they should construct a strong written argument based on data. Later, I provide them with feedback about their conclusions and evaluations. I think that the feedbacks I provided after the argumentation course are clearer. I mean that I like the way I give feedback now because before this course, I could feel that there is something missing in students’ arguments but I was not able to

describe what is missing. Now, I can name it. For example, I say that 'well, this is your conclusion. Here is your claim but where is your support, where is your data?' or 'well, this is your claim but you need to point out to the weaknesses of your claim'. I think that my feedback is more effective after the course." (Asya, PI)

Similarly, Birhan mentioned the contribution of the course to her teaching science such that

> "I had a chance to implement argumentation in my own classes. We have already decided to increase the number of activities in our school. I will tell you something else. We assign science homework via internet so we save time for more activities. I have been preparing one of them. We are planning to publish an activity book, like a notebook maybe. I think that the activities I prepared would be more argumentation-based in terms of the structure of the activity and the questions I ask because my thinking is shaped by the course and shifted from traditional teaching approach. I may not be able to teach the entire lesson as argumentation-based but there might be instances of argumentation, at least in my activities. I already made a presentation about argumentation to teachers to disseminate the argumentation." (Birhan, PI)

Summary

As in the evaluation of the initial design solution, I empirically tested the refined design solution and investigated the operative as well as inadequate aspects of it. Throughout, I also tracked the changes in the participants' theoretical understanding of argumentation in science teaching and learning.

The results related to the refined design solution can be summarized as;

- The refined design solution contributed to the participants' knowledge related to argumentation in terms of their understanding of argumentation theory and process as evidenced in their reflection papers, statements of argumentation, and post-interview data. However, the emphasis placed on the theoretical knowledge in the first classes made the progress harder for the participants.
- The content of the graduate course were presented as combination of theoretical background and associated activities. The presentation and the content of the course were effective in the sense of achieving the objectives of the course as evidenced in the reflection papers of the participants. However, the backgrounds of the participants' were diverse and so were their learning

needs. Therefore, the focus shifted from theory to practice or vice versa in the process.

- The participants' understanding of argumentation improved at varied levels depending on their focus and learning needs over the graduate course as evidenced in their statement of argumentation and post-interview data. However, the level of their arguments in the post-interview was generally low because of the inadequate knowledge they had on the subject of argument provided by the question.

3.5. Conclusion

In this chapter, I described the development, implementation and evaluation of a graduate course aimed at professional development of the participants on argumentation in science teaching and learning.

There were two research questions with respect to the aims of the development of design solution. The first one was related to the elements of a design solution developed in order to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning. Loughran (2014) asserted that such programs "must be purposefully conceptualized, thoughtfully implemented, and meaningfully employed" (p.10). In doing so, he suggested that the educators should carefully examine their own professional background in search for the opportunities that provided them with active development in their expertise (Loughran, 2014). With the purpose of developing theoretical understanding in argumentation, first, I conceptualized my objectives for each section and reviewed the research articles and activities for the ones that helped me achieve the objectives in my learning. Second, I reviewed the related literature to examine the components of teacher education on argumentation to decide the elements that were crucial for the learning and teaching in the context of argumentation.

In conclusion, the elements of the design solution were

- The knowledge of argumentation strategies and the pedagogical knowledge in the context of teaching argumentation along with the theoretical knowledge that would explain the core principles and goals through appropriate readings from the literature and through teaching practices (as suggested by Zohar (2008)).
- The environment that would support reflection and feedback regarding the participants' actual teaching practices in science classrooms that was reported in chapter 5 (as suggested by Clarke and Hollingsworth (2002), Hall and Sampson (2009), Hewson (2007), Hoban (2002), S-TEAM (2010), and Zohar (2008)).

- The involvement of the participants in the planning of the learning activities by means of their reflections and discussion questions in order to promote the learners' ownership and their understanding of the goals of the course (as suggested by Erduran and Yan (2009), Fraser (2007), Wallace and Loughran (2012), Zohar (2008)).
- The plenty of opportunities through activities to help participants have an experience in different aspects of challenging argumentation in various areas of science as suggested by Zohar (2008) (listed in the planned tasks for the course in Appendix C, p.347 and syllabus in Appendix E, p.360).
- The dynamic community of learners involving the facilitator to share experiences and promote collective participation (as suggested by Desimone (2009))
- The teaching practices that provided occasions for action to test to what extent the theory works in practice in real science classrooms (as suggested by Hoban (2002))

The second research question was about the changes in the participants' understanding of argumentation over the graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning. The results of the process demonstrated that all elements of the design solution contributed to the participants' understanding of *argumentation as a theory*, *as a core process in science*, and *as a kind of discourse* in science education. Moreover, the participants drew conclusions regarding *the role of argumentation* in science and science education *for enhancing the conceptual learning, higher-order thinking*, and *understanding science as a way of knowing*. The participants' concept maps and their responses in the post-interview evidenced that all participants had meta-level knowledge of the theory and pedagogy of argumentation in science education at various degrees.

In overall, the design solution developed in this study was an example to teaching argumentation in higher education. In other words, in terms of the readings reviewed in the course and the discussions on the theory and practice of argumentation, the design solution offered a meta-level understanding of argumentation. The participants were teachers, who were pursuing a graduate degree, and graduate students, who were going to be teacher educators. Hence, the content of the design solution encompassed research articles, book chapters, PhD dissertations and a meta-level discourse about all the readings. In this sense, the design solution targeted higher education rather than an in-service teacher training program.

3.6. Limitations of the study

The resultant arguments in the conclusions constituted limitations in respect to my dual role as the facilitator and the researcher, and the time afforded for the evaluation of the design solutions.

As being the facilitator of the design solutions, I actively interacted with the participants throughout the study. In other words, I was involved in the naturalistic research environment and my involvement contributed to my data generation in the sense of constructing meaning from the data. However, being an active agent of the learning environment may have also restricted my ability to see alternative meanings that can be drawn from the data.

In addition, although the analysis, exploration, design and construction took more than a year, the evaluation of the initial and refined design solutions lasted for fourteen weeks per se. Therefore, the time was limited for drawing further conclusions in regard to the shift in the participants' views of argumentation and argumentation-based science lessons. The time afforded was debatable in terms of achieving a full transformation in the participants' approach to theory and pedagogy of argumentation. Therefore, a follow-up observation of the participants' in their teaching for a longer time have potential to reveal more detailed descriptions of the changes experienced by the participants as a result of their learning and teaching in the course of design solution. Moreover, such a long-term observation may help the researchers to generate more data regarding the factors that promote or impede the participants' implementation of argumentation lessons.

3.7. Implications of the study

The process of this study in addition to the conclusions reported have important implications for the professional learning programs and graduate level courses on argumentation that aim to develop teachers' or graduate level students' understanding and pedagogy of argumentation, for the research on the pedagogy of teacher education or education of teacher educators on argumentation.

In the context of the course developed in this study, argumentation is considered as a body of knowledge that the participants need to possess in order to address it effectively in their classrooms, because as it is frequently noted in professional development research, teachers cannot teach something they do not know (Zohar, 2006). To decide the equivalent subject-matter knowledge in the context of argumentation, the relevant literature is examined in terms of the clarification of the concept of argumentation, examination of its significance for science instruction, discussion of its implications for the nature of teacher knowledge in this area and how it may be expressed in teachers' perspective and practice. The eventual design solutions were empirically tested, reflected upon, and were found to be successful. Therefore, the design solutions proposed in this study can be further developed in the light of the data, conclusions and suggestions provided in this study, and learning trajectories for science teachers and graduate students in learning to teach argumentation can be advanced based on the educational design research exemplified in this study.

The participants of this study were coming from diverse backgrounds and were at different levels in their career. As a consequence, their learning needs, interests and developments differed significantly. Therefore, this study does not offer one definitive model of argumentation development that can be applied to all. Instead, the reflections of the participants and the evidence of the shift in their beliefs and practices toward argumentation as well as my reflections along with the feedbacks provided by others may guide the researchers in this area in their planning and implementation. In sum, the conclusions that might influence the research and practice in teacher education on argumentation were drawn from the study. For example, the study demonstrated the necessity of providing physical and cognitive spaces for the participants to reflect upon their learning, the need to be flexible with the implementation of design solutions, and recognizing each learner's own authority to choose and perform their beliefs and practices in their own way.

CHAPTER 4

SCIENCE TEACHERS' INSTRUCTIONAL PRACTICES IN ARGUMENTATION-BASED SCIENCE LESSONS AND THEIR REFLECTIONS

This chapter describes the theoretical contribution of the research. In the chapter, a comprehensive literature review about the instructional strategies in argumentation lessons was provided. The research results comprised the teachers' and graduate students' instructional strategies in their lesson plans and teaching practices along with their reflections in order to reveal their progress in incorporating argumentation into their science lessons.

4.1. Introduction

The research indicates that using argumentation approach in science instruction is a challenging practice for many science teachers since they must not only go beyond adopting the curriculum or understanding the requirements of educational reforms, but also must know the argumentation strategies and be proficient in carrying-out evidence-based argumentative activities (Zembal-Saul, 2009; Zohar, 2008). On the contrary, the research indicates that teachers are either not familiar to such an approach aligned with constructivist and inquiry-based teaching approaches (Jiménez-Aleixandre, 2008) or not comfortable since teaching argumentation requires a fundamental shift in the pedagogies that they already use (Simon, Erduran, & Osborne, 2006; Zohar, 2008).

Previous research suggests that integrating argumentation effectively into science classrooms is demanding for science teachers (Simon, Erduran, & Osborne, 2006). Science teachers, for example, need to understand the role, importance and distinctions of scientific argumentation (McNeill & Krajcik, 2008), to be able to establish classroom culture encouraging argumentation among students (Berland & Reiser, 2009), and to view argumentation as a way to promoting student learning. However, sufficient knowledge about the new practices is not the only requirement for teachers to change their classroom practice (Sampson & Blanchard, 2012). Research indicates that teachers tend to give priority and use the instructional strategies that they think are effective (Keys & Bryan, 2001).

Indeed, it is a hard task for teachers to change their instructional strategies. It requires teachers to share the values of the new motive and be prepared to take threats (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010), have a desire to change their current practices, have opportunities for action, share their experiences with a community of practice, reflect in order to understand the emerging patterns of change, extend their knowledge and experience; and finally have time to adjust to the changes made through a continuous professional support (Hoban, 2002). Moreover, it takes significant time to begin to use new instructional practices in a competent manner, and teachers should be supported with continuous reflection and feedback in order to feel self-confident to introduce new practices in their classrooms (Clarke & Hollingsworth, 2002; S-TEAM, 2010; Zohar, 2008). Furthermore, Fraser et al. (2007) suggest that opportunities that allow greater ownership and control of the processes are likely to attend to more facets of the personal and social aspects of learning and are therefore more likely to result in transformational professional learning for teachers.

Therefore, in professional development programs for argumentation, teachers are introduced to argumentation as well as a range of different kinds of argumentation activities and pedagogical strategies; to develop their pedagogic practice with argument, and they are asked to incorporate argument-based lessons (Erduran, Yee, & Ingram, 2011; Simon, Erduran, & Osborne, 2006; Simon & Johnson, 2008; Simon, Richardson, Howell-Richardson, Christodolou, & Osborne, 2010; Tiberghien, Vince, Coince, & Malkoun, 2011; Tümay & Köseoğlu, 2010). That is because the educational requirements that come with integration of argumentation need to be reflected in the methods and instruments that support the learning and teaching process, including the design methods and tools.

Similarly, this research started with argumentation theory to develop a design solution by applying the principles of educational design research to address the teachers' and teacher educators' learning and teaching needs in the context of argumentation in science education and to frame the research process. Educational design research contributes to both theoretical understanding and practical applications (McKenney & Reeves, 2012). Theoretical understanding is the main input in educational design research because the researcher starts with a theory to design an intervention and frame the research process. It is also main output since the researcher advances the initial theoretical understanding by findings generated through the iterative process of educational design research. In this study, the instructional practices performed by the participants' in argumentation-based science lessons were the main theoretical output since the initial theoretical understanding was enriched by findings generated through the iterative process of educational design research.

In general, educational design research conducted through interventions yields theoretical understanding that describes and explains certain phenomena (McKenney & Reeves, 2012). Therefore, the theoretical understanding proposed in this chapter, which was emerged from the research conducted through the graduate course, was descriptive and explanatory. It was descriptive in terms of its attempt to describe how teachers and teacher educators develop pedagogy of argumentation and was explanatory because it contributed to explaining how an educational design can be used to advance the practice of teachers in relation to argumentation. The level of contribution to the theoretical understanding was essentially at local level since only several iterations of one basic design solution were studied in just two academic terms.

Therefore, in this part of the study, I described and explained the science teachers' and graduate students' teaching practices in terms of the instructional strategies they implemented to integrate argumentation in science classes in three instances of a graduate course, which was designed to develop their knowledge and practice with respect to argumentation in science classrooms.

4.1.1. Purpose of the chapter

Building on the abovementioned literature, and working with teachers and graduate students, who will be future teacher educators, therefore, in this study, I sought to investigate whether an educational design solution aimed at developing knowledge and practice in argumentation would enable them to develop a pedagogic practice that made improved use of argumentation in their teaching.

Meanwhile, the instructional strategies that the teachers adopted for their teaching based on their theoretical understanding are also a major concern in this study. Therefore, the purpose of this chapter is to reveal the theory and practice gap experienced by science teachers and graduate students in the context of argumentation in science classrooms.

4.1.2. Significance of investigating teachers' instructional practices

As has been explained in the purpose, the main significance of the study is its theoretical contribution to understanding how teachers knowledge of argumentation have found place in teachers' practices. The participants of this study, who were science teachers and graduate students, were enrolled in a graduate course designed to provide theoretical background and pedagogical knowledge in order to promote the integration of argumentation. The graduate course provided the participants with meta-level knowledge about argumentation through a research based cycle of intervention. However, we have little understanding of how teachers transfer their knowledge and understanding about scientific argumentation or of the extent to which they are able to enact the strategies they have learned in professional development opportunities, like the course in this study, in the teaching and learning of science. Therefore, this study was designed to help address this issue.

Another significance of the study is understanding how teachers perceive their practices. This study contributes to understanding the teachers' perspective in integrating argumentation in terms of the struggles they experienced, their views about the theory-practice compatibility, and the value they attributed to the argumentation in science education.

The participants' views are particularly important in this study because the participants of this study were teachers who volunteered to develop their knowledge and practice already, so they willingly participated for this practice. Moreover, throughout the study, they analysed and synthesized information from the educational literature on argumentation so they had a meta-level understanding of argumentation and its role in science education. Furthermore, some of the participants were going to be future teacher educators so their views and practices will most probably be influential on science teachers to whom they will teach. I think their views are important because they represent a special group due to these characteristics they had. Therefore, their practices as well as their views will be an indicator of the extent to which the propositions of the educational research is transferrable or applicable into the practice within the limitations of this study. Without this, current efforts to design professional development programs will, in all likelihood, be restricted to the theoretical presuppositions of the policy documents, curriculum, or academic journals (Sampson & Blanchard, 2012).

The third significance is demonstrating how self-reflection, peer feedback and expert scaffolds interact and contribute to teaching practices integrating argumentation. In this study, the participants reflected on their teaching practice in science classrooms and they received feedback from the other participants, who had their own teaching practices. Moreover, I, as the facilitator of the course, and my supervisor, as the expert on teacher education and curriculum, offered scaffolding for the participants in the planning and evaluation of their teaching practices. Therefore, the study also demonstrated the contribution of these interactions to the development of the argumentation-based teaching practices of the participants.

4.2. Literature Review

4.2.1. The impact of teaching strategies on students' argumentation

There are several factors that have an influence on students' dialogues and the kinds of arguments they constructed. For example the context, which includes the social dialogical opportunities and the learning environment allowing space for argumentation, the contextualization of the subject matter as well as the instructional strategies that teachers employ during any discourse are of these factors (Kolsto & Ratcliffe, 2008; Simonneaux, 2008). Osborne, Erduran and Simon (2004) argued that appropriate pedagogical practices need to be developed in order to enhance the quality of students' arguments. Yet, examples of such practices are few in educational literature that explored teachers' instructional practices in support of students' scientific argumentation (Erduran, Simon, & Osborne, 2004; McNeill & Krajcik, 2008).

One such example is the study by Erduran, Simon and Osborne (2004) conducted as a component of a project titled "Enhancing the Quality of Argument in School Science". In this project, a group of middle school science teachers attended in workshops, where they were familiarized with the strategies for encouraging students' use of evidence in an argumentation. These teachers, then, were observed in their classes to identify the pedagogical strategies they used to enhance the teaching of argumentation. The researchers studied TAP figures for teachers over two years to investigate the trends in the teachers' development in use of argumentation. In addition to the conclusions drawn regarding the teachers' use of pedagogical strategies to enable argumentation, the researchers also reported that collective reasoning in classroom was strongly affected by the nature of teaching (Erduran, Simon, & Osborne, 2004).

Günel, Kıngır and Geban (2012) specifically investigated the instructional strategies and questioning levels in the classrooms, where argument-based inquiry approach was implemented. The study aimed at exploring the relationship between levels of questioning that teachers directed and negotiation of ideas in whole class setting. The participants were three teachers and 146 students. The discourse analysis of the video transcripts of teaching practices resulted with the establishment of the relationship between levels of teachers' questioning and implementation of argument-based inquiry approach and starting and sustaining of the negotiation in science classrooms. For example, teachers' questioning patterns had found to be influential in the number and type of questions generated by the students. The researchers identified that the teachers' talk moves enabled more of students' talk and negotiation (Günel, Kıngır, & Geban, 2012).

In another study, McNeill and Krajcik (2008) explored the influence of teachers' different uses of the explanation framework, which was constructed by the researchers based on the Toulmin's model of argument, on student learning. During a middle school chemistry unit, the teachers were provided materials, which illustrated three conjectural examples of weak and strong explanations. Thirteen teachers' classes were videotaped for their implementation of the lessons. The results showed that the least support for students was provided for reasoning, and as a result, the students had the most difficulty with this component of scientific explanations. The study also provided with evidence on the teacher practices that influenced student learning of scientific inquiry practices. The researchers reported differential student learning in the same learning unit due to teachers' instructional practices (McNeill & Krajcik, 2008).

Recently, Pimentel and Mcneill (2013) conducted a study to investigate teachers' approaches to discussion and their beliefs about science talk. The course was the pilot study of urban ecology curriculum, which was designed to support underrepresented students' participation in science discourse. There were five teachers, whose teaching experiences range between 2 to 13 years, participating in the study. The teachers were enrolled in a summer professional development workshop, aimed at reinforcing their understanding of content knowledge and various pedagogical strategies that could be used to support the inquiry approach forwarded by the curriculum. Analysis of the students' responses demonstrated that students did not include their reasoning of their own accord in a discussion. Rather, the teachers' approaches to framing and moves in whole-class discussions fostered the limited students' responses (Pimentel & McNeill, 2013).

Similarly, in her PhD dissertation, Promyod (2013) investigated the changes that Thai teachers experienced in their views of learning and in their pedagogical practices in sense of designing lessons by using an argument-based inquiry approach. The participants were five physics teachers. The teachers were observed while they were teaching 'Foundation Physics' and 'Advanced Physics' to high school classes. The results of the study illustrated that as their views of learning shifts to be more inquiry-based, the instructional strategies that the teachers started using geared to a high cognitive level. For example, the teachers created activities that focused more on critical thinking skills. The students were asked to explain their reasoning and procedures in addition to their observations or answers. The researcher reported that as teaching strategies shifts to be more challenging, students had better chances to discuss, construct their own questions, and reason about their solutions. The conclusion was that the shifts observed in teachers' pedagogical practices to be more inquiry-oriented were resulted with student-centred classrooms (Promyod, 2013).

The abovementioned studies adequately illustrate the role of teaching strategies in promoting students' argumentation in science classrooms. As regards to the development of teaching strategies, the research evidence shows that professional development opportunities can support teachers in their successful enactment of instructional strategies targeting a specific learning goal in their classrooms (Jeanpierre, Oberhauser, & Freeman, 2005). However, a more nuanced investigation of these instructional strategies is required while teachers' knowledge and understanding of argumentation advances.

4.2.2. Instructional strategies in argumentation lessons

Based on the contention that teachers' moves in argumentation has a central and distinctive role in the students' practice of argumentation, there are numerous attempts to identify the roles of teachers in integrating argumentation into science education. For example, Kelly and Chen (1999) reviewed the research on scientific discourse and discourse processes in science classrooms, based on the variations in the students' written scientific discourses, the researchers realized that some elements in the instructional practices were missing. For example, the teachers did not make an explicit instruction regarding the scientific discourse or did not draw attention to the norms of the scientific community. The researchers claimed that without being unconcerned about the interpretive flexibility, the teachers need to have a discussion of the definitions related to empirical claim, a theoretical assertion, or a consistent argument. Such a discussion would make the implicit assumptions regarding these concepts explicit to the students. Another strategy suggested by the researcher was that the modelling of the argumentation practices to address the need to observe several of examples from the teachers (Kelly & Chen, 1999).

In a similar vein, Patronis, Potari, and Spiliotopoulou (1999) explored the arguments used by students in decision-making on an issue and proposed that teachers' intervention and evaluation of students' argument may offer opportunities for students to become more involved in the issue of debate and to validate their previous arguments in a more integrated and detailed way. As an example to these interventions, the researchers suggested that the teacher may appreciate the relevant scientific knowledge that the students used in their arguments and direct questions or ideas for elaboration. When the evidence do not relate to the necessary scientific knowledge, the teachers are suggested to offer new information, and help students re-examine their arguments or consider alternative aspects of the issue. The researchers argued that by means of these interventions, the scientific knowledge takes a comprehensive and integrated form with personal values, context and prior knowledge (Patronis, Potari, & Spiliotopoulou, 1999).

According to Garcia-Mila and Andersen (2008), there are more to this set of strategies that particularly related with Walton's (2001) argumentation schemes. In the achievement of the goals of discursive practices, the researchers suggested that the crucial developing element is metacognition in the form of either meta-strategic or metacognitive awareness. In other words, at the heart of debate, there is the epistemological capability to differentiate between sources of knowledge (Garcia-Mila & Andersen, 2008). Similarly, Kuhn and Udell (2003) proposed that for the argumentation strategies to increase, there is need for consistent practice and development of the associated skills as well as an enhanced meta-level consciousness of task goals.

Zohar (2008) also pointed to the epistemological meta-knowing. Epistemological meta-knowing was related to the way of conceptualizing knowing and knowledge. The researcher proposed that most people never progress to the level of understanding "how informed opinions are based upon the weighing of alternative claims in a process of reasoned debate and understand the depth of argumentation as a process involving alternative views and evidence" (p.256). The researcher suggested the use of the oral contribution of the teacher for promoting argumentation, as well as the use of writing probes to focus on the need to explain how we know what we know and why one knows, to justify arguments with evidence and reasoning, or to think about alternative viewpoints and evaluate them. By means of teachers' oral contribution or written probes, the researcher proposed that the "how" component of meta-strategic knowledge regarding argumentation can be made explicit for emphasizing the way sound argumentation should be carried out in the science classroom (Zohar, 2008).

To illustrate, an autobiographical study by Mork (2005) revealed a typology of teacher's role in the management of argumentative role-play debates. In this study, Mork (2005) used a web-based teaching programme about ecology in order to model different ideas and alternative solutions to a problem, and to practise argumentation. As a result, the researcher identified various interventions that teachers can employ in argumentative activities. For example, challenging the validity of information, extending the range of the debate, keeping the debate on track and alive, promoting students' involvement and focusing on debate techniques are the interventions found in each typology. These interventions were apparent in instructional strategies, such as asking for elaboration, rephrasing, addressing questions to specific students or giving students permission to speak. The author suggests the use of these strategies to influence the content and the flow of discourse, to encourage students to elaborate more on content, and to focus the discourse on the theme (Mork, 2005).

Another study by Simon, Erduran and Osborne (2006) focused on the instances that the teacher's contribution enabled and supported oral argumentation in elementary schools. In these instances, the researchers identified the strategies that individual teachers used in their classrooms to make the discourse more argumentative. They looked for how teachers supported classroom culture enabling student discussion and the use of evidence in students' arguments. In the paper, the pedagogy and discourse of five teachers' were studied. Addressing the same study, Erduran (2008) reported that the study resulted with a typology for the classification of pedagogical strategies used by teachers in the teaching of argumentation. The results showed that there were some strategies that reveal the epistemic goals during argumentation. For example, teachers, who value talking and listening to others, tend to give privilege to modelling and exemplification, position themselves within an argument and justify their position using evidence, construct and evaluate argument along with counter-argument and debate, and reflect upon the argumentation as a way of knowing. Another example was playing the role of devil's advocate as a pedagogical strategy to encourage students' use of justifications (Simon, Erduran, & Osborne, 2006).

To this end, educational research suggested that the teachers' roles in argumentation involve modelling and guiding inquiry (Jiménez-Aleixandre, 2008), encouraging students to justify their positions with evidence (Simon, Erduran, & Osborne, 2006), asking open-ended questions to elicit justifications (Jiménez-Aleixandre & Pereiro-Munoz, 2005; Simon, Erduran, & Osborne, 2006), challenging ideas by emphasizing their weaknesses or inconsistencies (Mork, 2005), proposing criteria for the construction and evaluation of arguments in the form of prompts (Osborne, Erduran, & Simon, 2004) or written rubric (Sandoval & Reiser, 2004; Sampson & Clark, 2008), revealing epistemic goals in the contributions they made (Simon, Erduran, & Osborne, 2006), encouraging students' reflection on the changes in their own views as a result of argumentation and on the reasons associated with these changes (Jiménez-Aleixandre, 2008).

4.3. Methodology

This section outlines and describes the methodology that was used in investigating whether an educational design solution aimed at developing knowledge and practice in argumentation of the participants would enable them to develop a pedagogic practice that made improved use of argumentation in their teaching.

4.3.1. Research Questions

The research questions with subsidiary questions are:

1. What are the instructional strategies science teachers and future teacher educators make use of in the planning and classroom practices to implement argumentation over the graduate course?
    a. Does a cycle of reflective practice, based on the use of argumentation, enable science teachers to implement instructional strategies to promote argumentation in their teaching practice?
2. How were the theory and practice gaps revealed with regard to argumentation in science education?
    a. How was the science teachers' theory-practice gap revealed in the experiences of the science teachers enrolled in the graduate course?
    b. How does science teachers' understanding of pedagogy of argumentation change over the graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning?

4.3.2. Participants

Participants were 1 elementary school science teacher and 2 high school science teachers who were enrolled in a graduate program, and 4 graduate students, who are going to be teacher educators. Detailed information about the participants was provided in Chapter 3 (see Participants, p.110).

4.3.1. Lesson planning

Lesson planning was the preparation phase for the teaching practices. The participants were free to design their choice of argumentation-based lesson plans. In other words, the participants were free which components to include in their lessons, which strategy they would use, how to evaluate the overall success of the lesson, and the format of the presentation. The activities to be performed, the resources to be used, and the materials to be utilized were chosen by the participants. During the planning, I provided scaffolding for the participants who asked for. There were three lesson plans designed by each participant, and two of them were implemented in real classrooms.

The first lesson plans were submitted in the sixth week of the course, the second lesson plans were submitted in the tenth week, and the last lesson plans were submitted at the end of the course. The participants were free about the format for lesson plans. Therefore, the lesson plans were in different lengths, the amount of details in lesson plans were different, and the participants either specifically addressed themselves as the teacher or designed the lesson plan for ‘a teacher’ so any teacher who have the lesson plan could be able to implement the course as described.

Most of the participants prepared lesson plans in a list format including the sections such as objectives, integration of nature of science and science process skills, the materials and resources, the introduction to the topic, the role of the teacher and the expectations from students, as well as the progress and the assessment of the objectives.

There were two noteworthy lesson plans in terms of the structure. One was the lesson plan prepared by Birhan. It was interesting to note that as a teacher, Birhan was preparing the lesson plan as short as possible and in certain steps. Her emphasis was on the activities. Moreover, the ‘teacher’s perspective’ was clear in Birhan’s lesson plans. In the entire lesson plans Birhan submitted, her sentences were so direct and brief that she just described what she, as the teacher, had to do and what she should be careful about in one or two sentences (Figure 3).

Grade	5th	
Unit	2th	Changing Matter
Theme	1st	Water Cycle
Duration	30 minutes	
Strategy/Technic	Argumentation	Predict-Observe-Explain
Type of Technic	Argumentative Discussion	
Integrated NOS	Emprical	

	Steps	Explanations	Limitations
What to do	1	Introduce lesson and activity	Teacher does not give the unit/objective name, nor the aim of the activity.
	2	Deliver the activity sheets	
	3	Direct students accordingly	Teacher does not direct students in a way that s/he gives the scientific explanations nor knowledge itself. S/he only directs the flow.
	4	Broaden the knowledge (Giving extra situations within the same activity.)	

Figure 3 The first lesson plan submitted by Birhan

On the other hand, the lesson plan submitted and implemented by Mesut was a very detailed one. To remind, Mesut was a PhD student, who had no teaching experience. As being a PhD student, he was expected to have had a well-established theoretical knowledge about teaching and learning in science education. Moreover, because he wrote an MS thesis on argumentation, he had a theoretical background on this area as well. However, because he had no experience in teaching, except internship, he had not planned a lesson for a real classroom teaching before the course. As noted earlier, the participants were free on their design of lesson plans. In a different way than the other participants, Mesut preferred a narrative format for his first lesson plan. He described all the details of the lesson in terms of classroom setting, teachers' role, and students' role, the aim of the lesson, the strategies, and the activities. For example, he stated the teacher's role as

> "During discussions teacher's role is as a moderator to lead the whole group discussion and prompt student(s) through critical thinking questions… In order to initiate small group discussion teacher first of all require students to create discussion groups. ",

or the students' role as

> "students are required to give their final answers, decisions and conclusions in 15 minutes."

or the aim of the lesson as

> "The purpose of this argumentative material is to provide students available data and also knowledge claims to generate their own arguments and argumentations during both small and whole group discussion."

In comparison to step-by-step lesson plan formats and general written frameworks applied by other participants, Mesut's first lesson plan was unusual. In his lesson plan, the process of lesson was described such that instead of giving directions to the teacher as himself, he was talking to 'a teacher'. In addition, his lesson plan was not only for the teacher because he was also clear about the expectations from the students. From this perspective, the first lesson plan was not only teacher-focused but it was also learning/ learner-focused.

4.3.2. Teaching practice

During the course, at three instances, the participants were required to design and at two instances implement argumentation-based lessons in science classrooms. Teaching practices were in-classroom experiences of the participants.

The schools where the participants practiced their teaching were diverse. For example, Birhan implemented her lesson plans at the elementary school where she was employed, so her communication with the students was already established. Similarly, Seher performed her practices in the private course where she taught chemistry to high school students. However, although she was employed as a chemistry teacher in a private school, Asya could not get permission from the school administration to try out a new approach because the school run through another program, so she went to another high school for practice. The other four participants were not employed as teachers in schools, so they had to find elementary schools to get permission for their practices. The number of students in each lesson was also different because while some schools allowed for whole class participation to the lesson, some others only allowed teachers to work with a group of students. The topics of lessons and details of the classes where the participants did their practices are presented in Table 3.

During their teaching practices, the participants video-recorded the whole class sessions. A week after their implementation, they brought these video-records or pieces of video records showing that they were implementing argumentation-based lesson to the graduate course for self-reflection and evaluation. As part of the graduate course, we watched these video-records with all participants, shared our views, and provided feedback.

The graduate course with the participants was active in that it was predominantly undertaken in a format where the participants discussed readings and ideas, reflected on materials and experiences, and shared student work. The process of reflection itself was an integral part of learning and the provision of effective professional development. Included in many models of teacher development, reflection often is an essential process for provoking change (Clarke & Hollingsworth, 2002). In this study, therefore, initiating the kind of change that was attempted was also dependent on the participants' efforts to integrate argumentation into their science teaching practices, sharing their experiences and reflecting on their own practices. To this end, after their teaching practice, the participants presented sections of videos showing their practice to reflect upon, discuss, and get feedback from their peers.

The communication between the participants and the facilitator was also worth attention. EDR has the potential to provide a direct link between research and practice by means of

Table 3 The details of teaching practices of the participants

	1st lesson			2nd lesson			3rd lesson
Participant	**Time (min)**	**topic**	**grade**	**Time (min)**	**topic**	**grade**	**topic/ grade**
Can	38.05	Heat transfer	6th	34.16	Sound transfer	6th	Environment-7th
Hilal	40.52	Absorption of light	7th	33.50	Solar system and beyond	7th	Cell division and heredity-8th
Birhan	53.58	Water cycle	5th	15.02	Mass and weight	6th	Chemical reactions
Mesut	37.48	Velocity	6th	42.54	Force	6th	Electric circuits-6th
Asya	31.02	Solution of gases	10th	29.34	Solubility of gases	10th	The effect of concentration on solubility-11th
Seher	39.34	Rate of chemical reactions	11th	32.07	Equilibrium in chemical reactions	11th	Radioactivity-11th
Mahmut	47.46	Modification mutation	8th	46.44	Particle nature of matter	6th	Evolution- 12

collaboration among practitioners and researchers in the identification of significant teaching and learning problems, in the development of creative solutions to these problems based on existing design principles, and in the evaluation and refinement of solutions and design principles (Kelly, Baek, Lesh, & Bannan-Ritland, 2008; Reeves, McKenney, & Herrington, 2011).This study was also the collaboration of several partners. To illustrate, first of all, the participants and I, as the facilitator and researcher, were always in communication face to face, by e-mail and by phone. We collaborated to revise and refine the graduate course and to prepare the learning tasks and plans that would be practiced in schools. I provided guidance for the participants' planning of their teaching practices, and I provided feedback during their reflections on their teaching practices.

4.3.3. Research Design

This part of the research has the characteristics of a qualitative study aiming at describing and interpreting the meaning of an experience from the researcher's and the participants' perspectives (Creswell, 2013; Merriam, 2002).

The approach to the writing of this part of research was a multiple-case study approach because in this part, my purpose was to explore and describe the shift in the participants' views of their teaching practices and their associated learning throughout the graduate course. This empirical method of writing allowed me to emphasize the features of the study, such as being conducted in a bounded system, while providing me with insight into the context by means of multiple data sources (Creswell, 2013; Merriam, 2002). In other words, here I focused on one specific situation, which was the shift in teachers' views of the teaching practices in terms of instructional strategies and the meaning they assigned to their experiences in terms of their learning. Therefore, this part of the study focused on understanding meaning-making process across each single case of how individual participants shifted their views of teaching practices and their associated learning over one semester of the graduate course through searching for common patterns (Stake, 1995).

According to Yin (2009), the aim in multiple case studies is not to control relevant behaviours of the participants; rather, the researcher attempts to explain, describe, and exemplify the real setting in a thick description, which is called holistic method. The various variables interacting each other within the context are taken into account, and they were utilized to explain the complexity of the setting (Merriam, 2002). Eventually, the readers were acknowledged with the holistic characteristics of the real situations and the multiple meanings of the phenomena from the researcher's and the participants' perspectives.

4.3.4. Data generation

Data sources included the participants' video-recorded classroom practices, audio-recorded reflections on their classroom practices, post-interviews with the participants, participants' written materials, such as their argumentation based lesson plans, their self-reflection papers, and the worksheets they collected from the students, to whom they taught.

4.3.5. Data analysis

Interpretive researchers, by studying teaching from all perspectives involving the viewpoints of those involved and classroom environment, try to provide a holistic view of the teaching conditions, interactions and processes. Therefore, the methodological approach is directed to generate rich information through qualitative data, and the presentation of the results become more narrative including the coding and categorising information but the cause –effect relationships are not established. In the research in line with interpretive paradigm, researcher is an active agent providing subjective interpretation of events and subjects as well as descriptions of observable behaviours, and should recognize that individuals may have different views of what is happening in the process of teaching or they may perceive the same environment differently. In the writing of results, therefore, the researcher should present factual information about the context and interactions (Schwartz-Shea & Yanow, 2012).

In this part of the study, there are two approaches to data analysis: Interpretive content analysis (ICA) of classroom practices (see Interpretive content analysis of classroom practices, p.41) and interpretative phenomenological analysis (IPA) of interviews and reflections (see Interpretative phenomenological analysis of interviews and reflections, p.42).

In this study, the transcripts of the participants' classroom practices are analysed by ICA in multiple cycles. In other words, I applied ICA for the analysis of each transcript of teaching practice for each participant. When a different code emerged, I turned back to earlier analysis I did and looked for whether I missed any similar conversation. This process was a multi-cycle process of analysis. I preferred ICA because first, my analysis was towards understanding the instructional strategies used by teachers while implementing an argumentation based science lesson in their classrooms. The texts are not studied in terms of the participants' use of language, as in the discourse analysis, such as whether the question asked is a high quality or not, or whether arguments are constructed appropriately, or what the components of an argument is. Rather, my focus was on the interactions and which interactions of the teacher resulted with argumentation or its justification. This focus is not directed to understanding the different uses of language for the same purpose. Therefore, as in latent content analysis, meanings were important rather than the structure. Second, content analysis is an example of unobtrusive research, which studies social behaviour without affecting it (Babbie, 2007). In this study, I did not enter the classrooms to observe teachers in their implementation so I did not affect their in-classroom practices. Instead, teachers brought the video-records of their practices for analysis purposes.

Baxter (1993) argued that the researchers who apply ICA often fail to report how they derived the coding categories and what their coding unit is. In this part of the study, I derived the coding categories from the literature and mainly from the studies by Simon, Erduran, and Osborne (2006) and Mork (2005). The categories regarding meta-strategic knowledge were emerged from the study by Zohar (2008). My coding unit was a chunk of the transcript, which illustrates some kind of teacher move attempting to initiate, sustain, or advance the argumentation that took place during the lesson. In other words, wherever a teacher's oral contribution to discourse reflected an explicit or implicit goal for the achievement of argumentation, it was highlighted and coded.

Moreover, Baxter (1993) criticizes ICA in the assumption that meaning can be categorized. This assumption leads researchers to ignore the emerging unique meanings, and to dismiss thick description for meaningful understanding. In order to overcome these difficulties associated with the trustworthiness of the data (see 2.5. Trustworthiness, p.44), specifically in conducting ICA, I explicated the theory guided this study, explained my method for coding, included example scripts to illustrate my coding, openly wrote my codes and my justification for the codes, and I provided a thick description of my understanding of argumentation and my background.

In this study, I performed IPA in analysing interviews with the participants and their reflection papers regarding each week of the course to capture and explore their perspective and experiences regarding argumentation and the designed graduate course on argumentation. I conducted semi-structured interviews with the participants, my advisors, and the participant-observer before and after the course, and I drew inferences based on the codes and subsequent themes derived from data from the interviews. In overall, the results provided me insight into different stakeholders' understanding and experiences regarding the design, and how they are interpreted in the framework of transformational teacher learning and argumentation theory (see 3.4. Evaluation and Reflection, p.168). In this part of the research, I reported my findings resulted from the interpretive phenomenological analysis of the participants' own reflections and interviews with the participants.

4.4. Findings

In this section, the findings emerged from the ICA and IPA analyses of the participants' teaching practices and interviews were presented to answer the research questions regarding: (1) how the instructional strategies science teachers and future teacher educators make use of in the planning and classroom practices to implement argumentation changed over the graduate course, and (2) how the theory and practice gaps were revealed with regard to argumentation in science education. In the writing, multiple case study approach was utilized. To present the findings from a holistic perspective, multiple data sources were combined for each individual participant under three headings: lesson planning, teaching, and reflections.

The findings and the inferences drawn from the findings were interpreted based on the codes and categories emerged during analysis. In the analysis, I did not focused on the frequency of these codes, as lessons were of different lengths and structure, but focused on whether the instructional strategies were apparent or not in the pedagogy and discourse of the seven participants. The codes are explained below.

4.4.1. Codes and categories for instructional strategies

In this section, the codes and categories emerged from the analysis of the participants' lesson plans and teaching practices were presented. There were six typology of teachers' pedagogy, named as argumentation specific pedagogical knowledge (ASPK), meta level pedagogical knowledge specific to argumentation (ML-ASPK), general pedagogical knowledge (GPK), meta level general pedagogical knowledge (ML-GPK), meta-strategic knowledge (MSK), and meta-strategic knowledge specific to argumentation (MSK-A).

4.4.2. Argumentation specific pedagogical knowledge

ASPK covers the instructional strategies apparent in the participants' teaching practices and lesson plans directed towards argumentation. The codes emerged in this typology were compared with the ones in the studies by Simon, Erduran and Osborne (2006) and Mork (2005) and were grouped in the same or similar categories (Table 4). However, the codes and categories constructed in this study are more refined to represent certain nuances between ASPK and meta-level ASPK.

For example, "evaluating arguments" is an instructional strategy that was drawn from the study by Simon, Erduran and Osborne (2006). The code can be generated in the process of teachers' evaluation of the use of evidence in argumentation. However, this study draws attention to the fact that "evaluating arguments" can be an instructional strategy that

Table 4 Codes and categories for ASPK -instructional strategies used by the participants

Categories of argumentation processes as reflected in teachers' contributions	**Instructional strategies derived from the literature**	**Instructional strategies used by the participants in this study**
Challenge the correctness	Rephrase and address question to other group	Asking for further arguments
	Asks for elaboration	Clarification of an argument/ claim(s) by questioning and/or rephrasing
		Clarification of counter positions for further argumentation by questioning and/or rephrasing
		Clarification of justification/ a rebuttal by questioning and rephrasing
Constructing arguments	Uses writing frame or written work/prepares presentations/gives roles	Constructing a problem/ a case for argumentation
		Drawing a writing framework to construct an argument
		Providing instructions for an activity
		The role of the students
Counter arguing/ debating	Encourages debate	Questioning for further arguments/ claims
		Questioning to elicit arguments
		Initiating argumentation
	Encourages anticipating counter-argument	Encouraging counter arguments
Evaluating arguments	Process – using evidence	Encouraging the use of data/observation/information as evidence
Extending range of topic	Asks for elaboration	Expanding a claim
Involve more students	Address question to individual or group	Asking for an argument

Table 4. (cont'd) Codes and categories for instructional strategies used by the participants

Categories of argumentation processes as reflected in teachers' contributions	Instructional strategies derived from the literature	Instructional strategies used by the participants in this study
Justifying with evidence	Checks evidence	Appealing to evidence
	Prompts justification	Asking for justification
	Plays devil's advocate	Playing devil's advocate
		Proposing (a) claim(s)/ counter-claim/ alternative claim(s)
		Proposing a counter-argument/ alternative arguments
		Proposing an alternative justification/ a counter-evidence/ a rebuttal
	Provides evidence	Providing evidence as experimental data/ figures/ pictures/ graphs/ scientific information/ statements
Positioning	Values different positions	Drawing attention to position/ counter position/ dilemma
		Guiding students to alternative arguments
		Encouraging the consideration of alternative/opposite ideas
	Encourages ideas	Encouraging more arguments
Reflecting on argument process	Asks about mind-change	Asking for mind-change
Talking and listening	Encourages discussion	Encouraging argumentation
	Encourages listening	Encouraging listening
		The role of the teacher

could be generated in the category of ASPK and also of ML-ASPK. In other words, teachers may evaluate the use of evidence as a general argumentative practice that was revealed as the argumentation proceeds or they may demonstrate an intentional planning and acting to evaluate the use of evidence depending on the context.

Moreover, I also provided my codes and categories corresponding to the ones by Simon, Erduran and Osborne (2006) and Mork (2005) in order to illustrate how a certain code or category that was taken from these studies might be coded in a number of different ways considering the nuances in teachers' practices.

Challenge the correctness

Mork (2005) developed a typology of teacher interventions and associated reasons in the study where she focused on teachers' role in relation to the management and teacher interventions in argumentation activities. As a result of the study, she identified six main reasons prompting teacher interventions and some sort of teacher action that each reason prompts. For example, the accuracy of content because of wrong use of concepts or wrong combination of information might be a reason for a teacher to challenge the correctness of information by rephrasing and addressing question to other group or by asking for elaboration.

Similarly, in this study, the teachers *asked for further arguments* and attempted to *clarify argument* or the components of argument, such as *claim, counter positions, justification or rebuttal by questioning and rephrasing*. For example, in the second lesson by Asya, at some point the students' arguments did not go further and the groups' combination of evidence cards was faulty. For this reason, Asya *rephrased and addressed question to other groups* in order to create an opportunity for challenging the correctness: (S for student and T for teacher)

00.23.07 (T) Why do you choose 3rd one when you compare 2nd and 3rd? Both of them are left in the same room. Their temperature is the same.
00.23.13 (S) No, we chose both of them
00.23.14 (T) You chose both?
00.23.08 (S) Yes
00.23.09 (T) Ok, I understand. Well, is there anyone who sees the difference between 2nd and 3rd?

(Asya, TP-1)

In another case, Birhan initiated a predict-observe-explain activity and asked students to predict what would happen if she puts a penny on a jar filled with hot water. The following script illustrated how she *asked for elaboration* to clarify the claims by questioning and rephrasing:

(In the scripts, the uppercased words were my notes indicating the teachers' or students' actions in argumentation)

00.16.07 (S) I think the penny will be warm- CLAIM 1
00.16.08 (S) Or the shape will change- CLAIM 2
00.16.09 (T) Shape of what?- QUESTIONING
00.16.10 (S) Penny
00.16.11 (T) Shape of the penny will change- REPHRASING
00.16.12 (S) Will look like....(not understandable)
00.16.13 (T) What?- QUESTIONING
00.16.14 (S) Will look like... (not understandable)
00.16.15 (T) I guess you mean it will expand. – REPHRASING Well, do you think that the purpose of placing this penny here is to change its shape or is there any other purpose?- QUESTIONING
00.16.16 (S) There might be another purpose- CLAIM 3.1
00.16.17 (T) What other purpose?- QUESTIONING
00.16.18 (S) Maybe to fit it into a shape- CLAIM 3.2
00.16.19 (T) Do you mean penny?- QUESTIONING
00.16.20 (S) No
00.16.21 (T) What is then?- QUESTIONING
00.16.22 (S) Glass, the condition under it- CLAIM 3.3
00.16.23 (T) Well, umm
00.16.24 (S) I think the outside thing will go inside the little glass, something like that-CLAIM 4.1

(Birhan, TP-1)

Constructing arguments

Simon, Erduran and Osborne (2006) identified this category with the ways in which teachers directed the students to construct arguments. For example, teacher *uses writing frameworks or written work, prepares presentations,* or *gives roles* as ways to ask students to construct their arguments on a worksheet, or to construct arguments commensurate with their roles in a role play situation.

In this study, the teachers encouraged students to construct arguments in a variety of ways. For instance, they *constructed a problem, a case for argumentation*, *drew a writing framework to construct an argument*, *provided instructions for an activity* promoting construction of arguments, or described *the role of students* in argumentation in their lesson plans.

OUR IDEA is;

In apartment ...., on the floor ...., we could live warmer with less gas consumption, because..
....
....

The evidence cards that support our idea are the ones with number.......................... because..
....
....

We do not agree with the other ideas because...

....
....

Figure 4 The writing framework used by one of the teachers to encourage students' constructing arguments

To illustrate, Can provided the students with a figure in his first lesson plan and promoted students' own arguments regarding the heat transfer. The students were asked to make a decision regarding which floor of an apartment was the best to live in winter. He also *prepared a writing framework* to guide students in *constructing arguments* (Figure 4).

Counter arguing/debating

The teachers encouraged counter arguing and debating through questioning for further arguments/ claims or to elicit arguments, by initiating argumentation or by encouraging counter arguments.

For example, Mesut, in his first lesson *encouraged debate* by directing questions for further argumentation;

> 00.03.23 (S) I want to talk about speed for your question. The definition of speed might be, according to what you said, in a definite hmm
> 00.03.24 (T) time interval?
> 00.03.25 (S) time interval, taking a certain road in fastest, how to say, with the most speed, wins or something like that.

00.03.26 (T) Then, according to the explanation our friend just made, who wins the race if car A, B and C kept their speed constant, in the fourth part?

(Mesut, TP-1)

In another case, Hilal *encouraged anticipating counter-argument* in an argumentation on the question “why do we always see the same side of the moon?”

00.09.29 (S) for instance, in the video we watched, it was always the red side because both are the same: both around earth and on its own axis, moon completes the rotation in the same time period.
00.09.30 (T) good but here you didn’t write like this here. Now, the groups who told that the reason for this phenomenon is because moon rotates and earth rotates, too: 1st and 3rd groups: if you want to refute the idea of these groups, how will you do that? Why is their idea wrong or right, what do you think?

(Hilal, TP-2)

Evaluating arguments

In terms of evaluating *the process- using evidence* component of argumentation, Seher clarified her goal regarding *the use of data/observation/information as evidence* in her second lesson. During an argumentation activity, which was about the chemical reactions, she encouraged the students to use the graphs provided in a worksheet in support of their arguments.

00.16.30 (S) I will make another explanation. Now the concentration will increase, it will be stronger and it would like to take more heat
00.16.31 (S) teacher, the third graph
00.16.32 (T) Ok, we need to make an explanation based on graphs, this is first.

(Seher, TP-2)

Extending range of topic

Mork (2005) indicated that during argumentation, teachers may realize that too few sub-topics are covered or there is incomplete information. In such cases, teachers need to extend the range of topic by means of pursuing particular parts of students’ utterances, ask for elaboration, reintroduce or introduce sub-topics. In a similar vein, the teachers in this study extended the range of topics by means of expanding a claim.

For example, in her first teaching practice, Birhan expanded a claim proposed by students on the topic of condensation;

00.16.25 (S) Teacher, the water will evaporate and then water vapour will stick to the stretch film. There, it will form a cloud- CLAIM 1
00.16.26 (T) Then you expect rain- CLAIM 1 EXPANDED
00.16.27 (S) Then there will be rain-CLAIM1.2

(Birhan, TP-1)

Involve more students

Considering the level of participation, in some cases, too few students may be involved in argumentation. In such a case, in order to *involve more students* into argumentation, teachers may *address the question to other individual or groups* (Mork, 2005). In this study, similar action of the teachers was coded as asking for an argument. For example, in his second teaching practice, Mesut asked the other groups' opinions regarding the competing theories he provided;

00.08.20 (S) teacher, we don't agree with sentence 1 because
00.08.21 (T) yes, the one you agree is important for me
00.08.22 (S) then, we don't agree with any of the sentences CLAIM
00.08.23 (T) you don't agree with any of them. REPHRASING What about the other group?

(Mesut, TP-2)

Justifying with evidence

Simon, Erduran and Osborne (2006) indicated that teachers often attempted to enhance the process of justification. There were four kinds of facilitation through which they supported justification.

For example, *appealing to evidence* code in this typology refers to the '*Check evidence*' code in the category of 'Justifying with evidence'. The dialogue was coded appealing to evidence when teachers question the validity or relevance of the evidence that the students used. For example, in the first teaching practice (TP) by Can, the students used evidence cards in support of their arguments. The topic of argumentation was the transfer of heat. Can provided the students with an activity, which required students use their knowledge about the transfer of heat to decide which floor of an apartment was the best to live in winter. In the following script, Can questioned about the evidences the students drew on to check whether they have a base:

00.00.43 (T) 7, 8 and 10. (referring to evidence cards) How these support you? QUESTIONING
00.00.49 (S) we thought convection would be more useful for us. Here generally, it talks about convection. For example, heat goes from the warm to the cold matter. In the convection warm air and cold air

exchanges their place and maybe warm to cold, heat is transferred. In eight ARGUMENT

00.01.08 (T) how is it related to the apartment example? QUESTIONING

00.01.11 (S) because there is convection in the apartment. Eight says that sun gives heat by radiation. The same thing; sun gives heat by radiation here. Ten says warmed air rises up. This is convection so it supports. ARGUMENT

00.01.26 (T) well, for A-2 you say supported by ten. When we look at the shape of the apartment, where is the warmed air? QUESTIONING

00.01.35 (S) here (shows by finger)

(Can, TP-1)

To encourage argumentation, all teachers tended to provide evidence as experimental data/ figures/ pictures/ graphs/ scientific information/ statements in their lesson plans and in their teaching practices. For example, in her first teaching practice, since there was no laboratory to search for experimental data, Seher *provided evidence* during argumentation;

00.21.29 (S) We see the mathematical equation for the reaction. It is said that 25 degree, 1 atm. I think my experimental set-up should meet these conditions. RESPONSE

00.21.30 (T) Do you mean that you should keep the temperature and pressure the same? REPHRASING (Yes) if you keep the temperature constant, the reaction rate might be the same or might be different.

(Seher, TP-1)

Teachers *prompted justification* when they wanted students to provide justification to their claims. As Simon et al. (2006) argued that these prompts are often in the form of questions such as “why?” or “how do you know?” One of the many examples is from Mahmut’s teaching practice. Mahmut provided statements for the students to consider. One of the statements was as follows;

00.01.36 (T) What does student A say?

00.01.37 (S) A says that if a man has a big body, his offspring have a big body, too.

00.02.03 (S) actually it is somehow correct. CLAIM

00.02.04 (T) how is it?

00.02.05 (S) for example, if my parents are tall, there is 95% chance of my being tall. WARRANT

(Mahmut, TP-1)

Teachers also *played devil’s advocate* in order to stimulate further justification of arguments in a number of ways. For example, the teachers in this study proposed (a) claim(s)/ counter-claim/ alternative claim(s); a counter-argument/ alternative arguments; or an alternative justification/ a counter-evidence/ a rebuttal;

00.08.03 (T) ok, well. The third group? What did you write?
00.08.11 (S) teacher because moon rotates on its own axis and around earth, we always see the same side of the moon.
00.08.12 (T) well, ok both moon and earth rotates on their own axes. Actually, the first group told the same. However, what I say is that the rotational period of the earth on its own axis and the rotational period of moon on its own axis or around earth are not the same.

(Hilal, TP-2)

Positioning

Argumentation proceeds in recognition that there may be different positions on a subject that might lead one to evaluate his/her claims in consideration of multiple views. Therefore, teachers would need to *encourage alternative ideas* in order that students would recognize that there were choices (Simon, Erduran, & Osborne, 2006).

In this study, the teachers demonstrated that they *value different positions* in their actions that drawing attention to position/ counter position/ dilemma, guiding students to alternative arguments, and encouraging the consideration of alternative/opposite ideas. For example, in her second teaching practice, Asya encouraged the consideration of alternative positions in a such a way that;

00.15.33 (T) which evidence cards did you use?
00.15.34 (S) as the temperature increases, the movement and speed of water molecules increase. This makes harder to keep gas molecules inside. JUSTIFICATION
00.15.35 (T) well, did you use this one only? (yes) did you use the second one? (no) why not?

(Asya, TP-2)

Reflecting on argument process

Simon, Erduran and Osborne (2006) indicated that teachers gave importance to encourage students to *reflect on the process of argumentation* by asking them about any change of ideas they had experienced as a result of argumentation. The message implicitly transferred here is that it is legitimate to change ideas or positions if you decide that an opposing argument is stronger as a result of argumentation.

For instance, Mahmut *asked for* students' *mind-change* as a result of argumentation about the concepts of element and molecule;

00.44.24 (S) in our group, the part after 'because' was not in accordance, so we changed that.
00.44.25 (T) what did you change?

00.44.26 (S) in the 4th item, we changed the part after ‘because’.
00.44.27 (T) what was your answer and how did you change it?
00.44.28 (S) in our answer, we summarized all such that the atoms composing the methane molecule are different. However, now we said that atoms are in different sizes.

(Mahmut, TP-2)

Talking and listening

Argumentation is only possible when students are able to work in groups, listening to each other and articulating their own ideas (Simon, Erduran, & Osborne, 2006). Therefore, teachers need to familiarize students to working discursively in groups and *encourage listening*. Hilal, for example, reminded students to listen to each other several times;

00.04.56 (T) Ok, we are listening to the first group. Let’s see what they think. It is a very interesting question. I guess there will be interesting answers. Everybody listen to your friend.

(Hilal, TP-2)

The teachers *encouraged discussion*, and specifically argumentation in students’ interaction. For instance, Can, in his first lesson encouraged argumentation among students by asking them to listen to each other and articulate their own ideas;

00.06.45 (T) Well, in the remaining time, let’s evaluate the groups. For example, what can the groups who do not agree with other groups say about their ideas? For example, 2nd group chose B-2, and 1st group chose A-2. What can the group who chose A-2 say about the items told by the other group who chose B-2?

(Can, TP-1)

The teaching practices of the teachers in the typology of ASPK were contrasted in Table 5, presenting the occurrence of the codes for seven teachers. The observed differences in emphasis that were reflected in the teachers’ lesson plans and teaching practices were expected considering the variety of themes in the classes, different grade levels, different lengths of the lessons, and the number of students involved in the teaching practices. In a similar vein, these differences between teachers were also apparent from one class to another for each individual teacher.

4.4.3. Meta-level pedagogical knowledge specific to argumentation

ML-ASPK covers the instructional strategies apparent in the participants’ teaching practices and lesson plans directed towards argumentation but requires meta-level thinking. In other words, teachers need to think and plan about implementing these strategies. Thus, in comparison to ASPK, teachers demonstrate an intentional planning

Table 5 Argument processes, codes for instructional strategies and occurrence of ASPK codes across two TP for seven teachers

Argument Process	Codes for instructional strategies	Can 1st TP	Can 2nd TP	Asya 1st TP	Asya 2nd TP	Seher 1st TP	Seher 2nd TP	Mahm 1st TP	Mahm 2nd TP	Hilal 1st TP	Hilal 2nd TP	Birhan 1st TP	Birhan 2nd TP	Mesut 1st TP	Mesut 2nd TP
Challenge the correctness	Rephrase and address question to other group	*	*		*						*				*
	Asks for elaboration	*	*	*	*	*	*	*	*		*	*	*	*	*
Counter arguing/ debating	Encourages debate		*		*		*	*	*		*	*		*	*
	Encourages anticipating counter-argument	*	*	*		*		*			*	*		*	
Evaluating arguments	Evaluates process – using evidence	*			*		*	*	*	*		*	*		*
Involve more students	Address question to individual or group		*									*	*		*
Justifying with evidence	Checks evidence	*			*	*	*			*			*	*	
	Prompts justification	*	*	*	*	*	*	*		*	*	*	*	*	*
	Plays devil's advocate		*			*	*	*			*	*		*	*
	Provides evidence					*									
Positioning	Values different positions		*	*	*	*		*		*	*		*		*
	Encourages ideas			*	*							*		*	
Reflecting on argument process	Asks about mind-change								*						
Talking and listening	Encourages discussion	*	*				*				*				*
	Encourages listening						*	*		*	*				

and acting in terms of the pedagogical knowledge specific to argumentation. The codes emerged in this typology were also compared with the ones in the studies by Simon, Erduran and Osborne (2006) and Mork (2005) and were grouped in the same or similar categories (Table 6).

Table 6 Codes and categories for meta-level ASPK -instructional strategies used by the participants

Categories of argumentation processes	Instructional strategies derived from the literature	Instructional strategies used by the participants in this study
Evaluating arguments	Evaluates arguments	Developing a rubric as assessment criteria
		Developing an assessment strategy for an argumentation lesson
		Drawing an evaluation framework for justification
	Setting expectations	Setting expectations for students' learning about argumentation
		Setting expectations for the quality of argumentation
Focus on debate technique	Drawing rules	Drawing rules for a teaching method/strategy
Knowing meaning of argument	Choosing/naming a specific strategy	Choosing a specific strategy to implement argumentation
		Naming a specific strategy to implement argumentation
	Identifying objectives/ purpose	Defining the objectives of a specific strategy

The researchers can differentiate whether an act is a meta-level or not in context. This decision requires the knowledge of the teachers' prior knowledge and strategies regarding argumentation as well as the common teaching practices found in a classroom. For example, a teacher move such as stating explicitly the objectives of the lesson might be a regular practice for the teacher. In such a case, this act could not be evaluated a meta-level instructional strategy. However, in contrast to the regular teaching practices, if teacher intentionally plans and calls the objectives in the classroom for that specific class, then this act for that individual teacher is a meta-level action.

Evaluating arguments

Simon, Erduran and Osborne (2006) categorized teacher utterances as *evaluating arguments* "when teachers had clear goals that focused on the evaluation of arguments and asked students to make judgements about exemplar arguments. In doing so, they either emphasized that having evidence is important or they focused on the nature of the evidence." (p.251). In this study, the category was extended to include the teachers' instructional practices that clearly target the objectives of the lesson and prepared on purpose, such as developing a rubric as assessment criteria, developing an assessment strategy for an argumentation lesson, or drawing an evaluation framework for justification.

For example, in her third lesson plan, Asya set clear goals regarding the evaluation of students' argumentation. She adapted an assessment strategy to evaluate students' posters and explained her strategy

"While the students are trying to decide on this, the instructor will hand out the paper named as "THE POSTER EVALUATION" paper to each group (Please see the same named attached file. This file was taken from Sampson's PhD study with some revisions). Each group will have 5 (their group is not included in this number since they are not going to evaluate their own group's work) of this paper since there are 6 groups in total. After handing out the poster evaluation forms to each group to evaluate the posters as a group, the instructor will go over the items in the evaluation form to clarify if there is/are any parts that were not understood by the students and then, the first group is asked to come to the board to present their poster. While a student presents the poster on the board to the other students in the class, he/she also answers the questions that are asked by the other students in the class and also, the rest of the students will provide their comments verbally on the poster based on the questions on the poster evaluation form." (Asya, LP-3, p.11, l. 230-242).

In a different way, teachers may have standards in their minds for the quality of students' argumentation or students' learning during argumentation. In this study, these standards were apparent in their lesson plans and these were coded as *setting expectations*. For example, in her second lesson plan, Seher stated that

> "Students haven't known Le Chatelier principle, yet. They are going to try to comprehend the mechanisms of the principle by inferring from data, which

illustrate how a specific factor affects the equilibrium of the reaction. They are going to answer the related questions by using the data and the evidence cards (graphs) provided. Their responses will be evaluated based on their use of data and evidence cards as well as the quality of their evidence-based judgements." (Seher, LP-2, p. 1, l. 13-17)

Focus on debate technique

Maintaining order of speakers in classrooms, where the students are not used to the debate techniques is another task that the teachers take. Mork (2005) indicated that in order to train students in how to behave in debates, teachers may give students permission to speak on turn. This move of teachers is considered to be focusing on debate technique, which aims at practicing argumentation skills.

In this study, the teachers *drew rules for the teaching method* argumentation or an associated strategy to familiarize students with the argumentation skills. For example, in his first argumentation teaching practice, Mahmut set rules regarding the argumentation process;

> 00.07.09 (T) There is no superior here; everyone has his/her own opinion. Everyone will defend his/her own idea. You came into groups. We talked about your individual opinions on the issue. Now, I will distribute clue cards to you. These evidence cards are evidence, that is, they are real. You will declare your opinions based on these cards, is it ok? Now, I distribute the first clue card to all groups. All clue cards are correct; they are taken from real examples. Please be aware of this in your discussions. All clue cards are relevant to the concept cartoon. When everyone is ready to talk about his/her own opinion on the clue card, you will choose a spokesman to tell us your idea in your group. I will give you 7 clue cards in sum, so please be quick.
>
> (Mahmut, TP-1)

Knowing meaning of argument

Simon, Erduran and Osborne (2006) indicated that teachers may make attempts to support students' understanding of what argument means. There are several strategies that teachers use for helping students understand argumentation. At a basic level, teachers may define argument, or exemplify argument. Also, through reflecting on the process of argumentation, teachers may also support students to develop an understanding of what argument is. This approach to coding focused on the teachers' moves in the classroom centred on teacher-student interaction.

In a different way, in this study, I focused on the teachers' pedagogical knowledge, which was not only reflected in their teaching practices but also in their lesson plans. In these practices, teachers' pedagogical knowledge in relation to knowing meaning of argument was also considered to be a meta-level knowledge specific to argumentation. For example, choosing and/or naming a specific strategy in relation to argumentation, or identifying objectives and/or purpose in relation to argumentation in their teaching practices or lesson plans require teachers' knowledge of argumentation as a way of learning science. Therefore, these attempts were coded as meta-level pedagogical knowledge specific to argumentation in the category of knowing meaning of argument.

For instance, Mahmut explicitly called a specific strategy to implement argumentation in his first teaching practice;

> 00.01.16 (T) We call this concept cartoon, which is a strategy for science education through cartoons. It asks that whether there is any effect of physical training on the offspring.
>
> (Mahmut, TP-1)

Similarly, Asya, in her third lesson plan, demonstrated her knowledge of argumentation by identifying objectives in relation to argumentation;

> "The purpose of this lesson is to conduct argument driven inquiry by making the students generate arguments as a result of drawing conclusions from their data collected through conducting the experiment of their own group design about the effect of concentration of reactants on the rates of chemical reactions and evaluating these results, and evaluate the alternative views provided by the other groups of students in the class." (Asya, LP-3, p. 2, l. 37-41)

The teaching practices of the teachers in the typology of ML-ASPK were contrasted in Table 7, presenting the occurrence of the codes for seven teachers. To remind, the observed differences in emphasis that were reflected in the teachers' lesson plans and teaching practices were expected considering the variety of themes in the classes, different grade levels, different lengths of the lessons, and the number of students involved in the teaching practices. In a similar vein, these differences between teachers were also apparent from one class to another for each individual teacher.

4.4.4. Meta-strategic knowledge specific to argumentation

Zohar defines meta-strategic knowledge as "general knowledge about the cognitive procedures that are being manipulated. It consists of the following abilities: making generalizations and drawing rules regarding a thinking strategy; naming the thinking

Table 7 Argument processes, codes for instructional strategies and occurrence of ML-ASPK codes across TP and LP for seven teachers

		Can		Asya			Seher			Mahmut			Hilal			Birhan			Mesut			
Argument Process	**Codes for instructional strategies**	1. LP	2. LP	1. LP	2. LP	3. LP	1. LP	2. LP	3. LP	1. TP	1. LP	3. LP	1. TP	2. LP	3. LP	1. LP	2. LP	3. LP	1. LP	2. TP	2. LP	3. LP
Evaluating arguments	Evaluates arguments				*	*		*	*			*			*			*			*	*
	Setting expectations	*	*			*	*	*														
Focus on debate technique	Drawing rules for a teaching method/strategy				*	*				*			*						*	*		
Knowing meaning of argument	Choosing/ naming a specific strategy to implement argumentation	*		*	*	*	*			*	*	*		*		*	*	*	*		*	*
	Identifies objectives / purpose in relation to argumentation			*	*	*	*		*										*	*		

strategy; explaining when, why and how such a thinking strategy should be used, when it should not be used; what are the disadvantages of not using appropriate strategies, and what task characteristics call for the use of the strategy." (Zohar A. , 2006; Zohar A. , 2008, p. 254; Zohar A. , 2012).

In this study, cognitive procedures that are closely related to argumentation were identified as constructing arguments, coordinating evidence, backing a claim, and providing justification (Table 8). The codes were derived from the studies by Zohar (2006; 2008; 2012).

Table 8 Codes and categories for MSK-A -instructional strategies used by the participants

Categories of argumentation processes as reflected in teachers' contributions	**Instructional strategies used by the participants in this study**
Drawing rules for a thinking strategy	Constructing arguments
Modelling the thinking strategy	Constructing arguments
	Coordinating evidence
	Providing justification
Naming the thinking strategy	Constructing arguments

Drawing rules for a thinking strategy

Zohar (2006) indicated that specific thinking strategies can be fostered in a specific lesson by means of purposefully designed learning activities. For example, teachers may enhance a discussion focusing on the main components of a thinking pattern and bring about generalizations and formulate rules in relation to this thinking pattern.

In this study, the teachers purposefully designed argumentation activities, and in some occasions, they taught the students the general elements of this thinking activity. For example, in his second lesson, Mahmut addressed a specific thinking pattern for *constructing arguments* repeatedly so the students could formulate the generalizations and rules by themselves;

00.28.38 (T) Have you had a discussion? What was your discussion based on? Have you had a disagreement?
00.28.46 (S) Do you mean difference?
00.28.47 (T) Yes, difference. Have you had different viewpoints?
00.28.51 (S) We agreed on the answers.
00.28.52 (S) We had different ideas but we agreed on
00.28.53 (T) What were your different ideas?
00.28.57 (S) For example, my idea was that the molecule is composed of two types of atoms. My friend's idea was that the molecule is composed of more than one type of atom. I mean, he was thinking that there are not only two types of atoms but there more.
00.29.09 (T) Do you mean that there are three types of atoms? (yes) well, how did you convince your friend?
00.29.17 (S) I said, the purple atoms are one type and the yellow atom is a different type.
00.29.18 (T) Therefore, you said that there are two types of atoms, not more than two. You used their colour as evidence.

(Mahmut, TP-2)

Modelling thinking strategy

Zohar (2006) proposed that teachers' knowledge of MSK may lead them to develop effective pedagogical tools for teaching higher order thinking. There are several components of such pedagogical tools suggested by Zohar (2006). One of them is the "knowledge of how to model the use of general thinking structures in a variety of specific circumstances, moving continuously between the levels of procedural and metacognitive knowledge" (p.339).

In this study, in the teaching practices of some of the teachers, such modelling was apparent in the teaching of higher order thinking skills such as constructing arguments, coordinating evidence, and providing justification.

For example, Mesut, in his first argumentation lesson, *modelled constructing arguments*;

00.06.28- (T) …Here, in the second part, there are three friends, there are statements, and there are some claims, related to the observations of the three buddies who went to race. You will try to show us "Are these claims right or wrong? If it is right, why is it right? If it is wrong, why is it wrong?" …Hasan, for example, there is a friend named Can here, agrees to Can's claim. He will say that "I agree with Can's claim because of this" or "this also supports my claim". First, we will do this in groups and then we will discuss as whole class.

(Mesut, TP-1)

In a similar vein, Can *modelled coordinating evidence* in his second teaching practice;

00.04.27 (T) I think you stuck at the evidence part. Let me ask you this: are you convinced that there is such a problem?

00.04.28 (S) Yes

00.04.29 (T) What was the thing that convinces you to the existence of such a problem?

00.05.07 (S) Because whales die

00.05.08 (T) Whales die

00.05.09 (S) The statement made by the US authority

00.05.10 (T) The official statement

00.05.11 (S) The data about the global warming

00.05.12 (T) The data about the global warming. What all these are: these are evidence. These and similar things like these are in the news. You can write those.

(Can, TP-2)

In his first teaching practice, Can also *modelled providing justification*;

00.09.04 (T) Maybe it is not our topic but for you to understand the topic and to clarify what you need to do, I will explain it with an example. What colour is our blood, not need to ask, everybody say red. However, look at your wrists. What colour do you see the vessels? Blue, a little purple and some green. Ok, the question is that if your blood is red, how the vessel looks like this? Your answer might be, there are claims here as in your clue cards. It says the vessels are blue. The second says that blood is red because of the oxygen. The third says that arteries are deep inside the body while the veins are closer to the surface. Veins carry oxygen-poor blood.

Now I am thinking to support a proposal. I may choose a number of them. Which one should I choose? The blood is red because of oxygen. And also I chose that arteries are deep inside the body while the veins are closer to the surface. As the last, I chose this one, too but as you see I neither did nor chose the first one. Now, what my statement may look like? Blood are red but vessels are not blue. The blood is red because of oxygen. I also chose the second one: arteries are deep inside the body while the veins are closer to the surface. And veins carry oxygen-poor blood. I need to set up a relationship between these. When I put them together what it looks like? Actually, what we see here are veins and veins carry oxygen-poor blood. Because arteries are deep inside the body, they carry red blood but they cannot be seen. Therefore, the vessels we see are veins. And why the colour is like this? Because the amount of oxygen carried by these are less. Think in a similar way and one or two minutes, be ready.

(Can, TP-1)

In his long explanation, Can demonstrated the use of different data (e.g. “look at your wrists. What colour do you see the vessels?”; “blood is red because of the oxygen”; “Veins carry oxygen-poor blood”) in justification of the claim (e.g. “Blood are red but vessels are not blue.”). He constructed a justified example by referring to each of the alternatives (e.g.

“Actually, what we see here are veins and veins carry oxygen-poor blood. Because arteries are deep inside the body, they carry red blood but they cannot be seen. Therefore, the vessels we see are veins. And why the colour is like this? Because the amount of oxygen carried by these is less”). Therefore, Can’s attempt to model how to construct justified arguments was coded as modelling thinking strategy- providing justification.

Naming the thinking strategy

In the teaching of higher order thinking skills, such as constructing arguments, coordinating evidence and providing justification, teachers should demonstrate the knowledge of the thinking strategies by explicitly calling them in appropriate instances of the class and should be able to explain when, why, and how to use these thinking strategies in the process of argumentation and problem solving (Zohar A. , 2006). Zohar (2006) explained the necessity of explicit teaching of the names of thinking strategies in MSK such that “Although teachers did seem to have considerable implicit meta level knowledge of scientific inquiry strategies, this knowledge was insufficient for the purpose of teaching higher order thinking in a sound and focused way. To facilitate such teaching, teachers must transform their implicit knowledge into explicit knowledge that can be mediated through the language of thinking. Only when the relevant MSK is indeed made explicit, does it become accessible for teachers’ use in their practice.” (p.368)

In this study, there were cases where the teachers name the thinking strategies either in their lesson plans or teaching practices. For instance, Mesut wrote about the thinking strategies that he aimed to foster in his lesson;

> “All lessons are argumentation based therefore the design of the lessons contain critical thinking processes such as generating arguments, counter arguments, rebuttals, justifications and etc. regarding given knowledge claims.” (Mesut, LP-3, p.1, l. 15-17)

The teaching practices of the teachers in the typology of MSK-A were contrasted in Table 9, presenting the occurrence of the codes for seven teachers. To remind, the observed differences in emphasis that were reflected in the teachers’ lesson plans and teaching practices were expected considering the variety of themes in the classes, different grade levels, different lengths of the lessons, and the number of students involved in the teaching practices. In a similar vein, these differences between teachers were also apparent from one class to another for each individual teacher.

Table 9 MSK processes, codes for instructional strategies and occurrence of MSK-A codes across TP and LP for teachers

MSK process		Drawing rules for a thinking strategy	Modelling the thinking strategy			Naming the thinking strategy
Codes for instructional strategies		Constructing arguments	Constructing arguments	Coordinating evidence	Providing justification	Constructing arguments
Can	1st TP				*	
	2nd TP			*		*
Asya	1st LP				*	
	2nd LP				*	
Mahmut	1st LP					*
	2nd TP	*				
Hilal	1st TP		*			
	2nd TP			*		
Birhan	1st TP	*			*	*
	2nd TP				*	
Mesut	1st TP	*	*		*	
	2nd TP				*	
	3rd LP					*

4.4.5. General pedagogical knowledge

GPK covers the instructional strategies apparent in the participants' teaching practices and lesson plans. In contrast to argumentation specific pedagogical knowledge, these instructional strategies are not specifically directed towards the achievement of argumentation related objectives or skills. On the other hand, the codes generated in this typology indicate complementary instructional strategies that will support argumentation.

The researchers can differentiate whether an act is a GPK or not in context. This decision mostly depends on knowing which part of the lesson is argumentation-based and in which cases the teacher facilitates argumentation. For example, all of the session might not be argumentation-based and there might be times, at which the teacher just set a background for initiating argumentation, or help students get used to the principles of argumentation such as talking and listening to each other, making groups for interaction and discussion, or conclude the lesson. These moves of the teacher were coded in the typology of GPK.

In the following, the most frequent codes in GPK are explained.

Drawing rules to coordinate group discussion

Argumentation is only possible when students are able to work in groups, listening to each other and articulating their own ideas (Simon, Erduran, & Osborne, 2006). Therefore, teachers need to familiarize students to working discursively in groups and *encourage listening*. However, teachers may encourage talking and listening as a regular practice in science classrooms rather than as a requirement of argumentation, as Mesut did;

> 00.01.43 (T) My friends, in this lesson, we will also learn how to be democratic socially. I mean, within group discussions we will be more quiet. Why? Because we don't want other groups to be disturbed or to be thrilled with our ideas. Additionally, while each group spokesman stands up and explain the group's agreed decision, what will we do? We will listen to him/her, we will respect. Let's each group has a name and spokesman.
>
> 00.02.56 (S) Teacher, what will spokesman do? Does (s)he solve a problem?
>
> 00.02.57 (T) No, no, they won't solve problems. …There is nothing actually that a spokesman will do. (S)he will just stand up and tell that this is the decision made in our group, we think like this, because of this/ therefore we think like that.
>
> (Mesut, TP-2)

Setting up background for a study

In most of the schools, students are rarely given opportunities for discussion, or specifically for argumentation, among their peers (Driver, Newton, & Osborne, 2000; Zohar & Nemet, 2002). Therefore, the teachers needed to prepare the students for such activities that require students' active collaborative action and decision making. For this purpose, the teachers assessed the students' background by questioning, identified the purpose and objectives in their lesson plans, and provided instructions prior to the activities.

For example, Asya in her first argumentation teaching practice *set up a background* and *provided instructions* such that;

> 00.00.38 (T) are you done? Have you read? Now, uncle Osman has an idea. According to uncle Osman's idea, he believes that he can catch more fish deep in the sea. Just below this, there is a question about

your knowledge about this idea. First of all, everybody will answer the question individually. Write your answer there.

00.01.01 (S) but it says the answer can be supported by evidence cards

00.01.02 (T) yes, the evidence cards are just at the back of the page. You can write these. In the instruction part, there are evidence cards. You can use those. First, you will answer individually. In the 'because' part, in the explanation part, you can use the evidence cards. Is there any question? You can use more than one evidence card. You don't have to stick to those, you can write something else.

(Asya, TP-1)

Summarizing the situation to arrive to a conclusion

At some points during discussion, the teachers summarized or concluded the debate because the ideas did not go further otherwise. For example, Hilal, in her second teaching practice *summarized* what the students talked about to that end to continue to the debate in another way;

00.10.41 (T) Yes, the main question is. What is it? Why do we always see the same side of the moon from earth? The 1st and the 3rd groups say that the answer to this question is that moon rotates around earth. It is ok. Earth rotates on its own axis, too. They say that because of this, we always see the same side of the earth. However, M says that this phenomenon is irrelevant to the moon's rotation around earth and on its own axis because their rotational periods are not the same. Earth rotates faster. Therefore, M refutes the idea of the 1st and 3rd group. Am I right?

(Hilal, TP-2)

The teaching practices of the teachers in the typology of GPK were contrasted in Table 10, presenting the occurrence of the codes for seven teachers. To remind, the observed differences in emphasis that were reflected in the teachers' lesson plans and teaching practices were expected considering the variety of themes in the classes, different grade levels, different lengths of the lessons, and the number of students involved in the teaching practices. In a similar vein, these differences between teachers were also apparent from one class to another for each individual teacher.

4.4.6. Meta-level general pedagogical knowledge

ML-GPK covers the instructional strategies apparent in the participants' teaching practices and lesson plans but requires meta-level thinking. In other words, teachers need to think and plan about implementing these strategies. Thus, in comparison to GPK, teachers demonstrate an intentional planning and acting in terms of the pedagogical knowledge specific to argumentation. In contrast to argumentation specific meta level pedagogical

Table 10 Codes for instructional strategies and occurrence of GPK codes across TP and LP for seven teachers

	Can			Asya			Seher		Mahm		Hilal			Birhan			Mesut		
Codes for instructional strategies	1st TP-LP	2nd TP-LP	3rd LP	1st TP-LP	2nd TP-LP	3rd LP	1st TP-LP	2nd TP-LP	1st TP-LP	2nd TP-LP	1st TP-LP	2nd TP-LP	3rd LP	1st TP-LP	2nd TP-LP	3rd LP	1st TP-LP	2nd TP-LP	3rd LP
Drawing rules to coordinate group discussion	*	*		*	*	*		*		*	*	*	*	*			*	*	
Setting up background for a study	*			*	*	*	*							*	*	*		*	*
Summarizing the situation to arrive to a conclusion	*	*							*		*	*		*			*	*	
Asking open ended question to initiate inquiry/ discussion		*				*		*				*	*	*				*	
Asking for an explanation								*	*	*		*		*					
Making groups for interaction and discussion	*	*	*														*	*	
Keeping discussion on track								*	*			*							
Making an explanation									*	*		*							
Identify an assessment strategy					*						*	*							
Concluding the discussion					*				*										
Probing reasons							*												
Focusing on the expected responses														*					

knowledge, these instructional strategies are not specifically directed towards the achievement of argumentation related objectives or skills. On the other hand, the codes generated in this typology indicate complementary instructional strategies that will support argumentation.

To recall, the researchers can differentiate whether an act is a meta-level or not in context. This decision requires the knowledge of the teachers' prior knowledge and strategies regarding argumentation as well as the common teaching practices found in a classroom. For example, a teacher move such as stating explicitly the objectives of the lesson might be a regular practice for the teacher. In such a case, this act could not be evaluated a meta-level instructional strategy. However, in contrast to the regular teaching practices, if teacher intentionally plans and calls the objectives in the classroom for that specific class, then this act for that individual teacher is a meta-level action.

In the following, the most frequent codes in ML-GPK were explained.

Naming the teaching method/strategy

Choosing and/or naming a specific strategy in relation to argumentation, or identifying objectives and/or purpose in relation to argumentation in their teaching practices or lesson plans require teachers' knowledge of specific instructional methods as a way of learning science. For example, a teacher move such as stating explicitly the name of the teaching method might be a regular practice for the teacher. In such a case, this act could not be evaluated a meta-level instructional strategy. However, in contrast to the regular teaching practices, if teacher intentionally plans and calls the name of the teaching method in the classroom for that specific class, then this act for that individual teacher is a meta-level action.

For instance, Mesut, in his first teaching practice initiated lesson such that;

> 00.01.03- (T) My name is Mesut. I am a science and technology teacher. Today, we will do the lesson together. Your teacher said "force and motion"; we will just make an introduction to the topic. And we will try to discuss an effect that a force causes. The course will progress through discussion.
>
> (Mesut, TP-1)

It is an unusual move for a teacher to state the teaching method or strategy in the class, therefore, this move of Mesut was included in ML-GPK.

Clarifying the aim

When the debate is on the edge of the original theme, the teachers needed to get debate back on track. They interrupted and reminded the students the aim of the debate several times during the lesson. For example, Birhan was coded two times for this strategy in the following scripts;

> 00.05.37 (S) I think the volume of water inside is 400 g (claim 4.1) because this beaker is 100 ml and this is 600 ml.(data 4.1) teacher how much did you pour? ARGUMENT 3.1
>
> 00.05.38 (T) I did not pour a certain amount because here if we would like to use our science process skills there would be questions related to this.
>
> (Birhan, TP-1)

Another coding regarding this strategy in Birhan's class was for the chunk that states;

> 00.12.07 (S) Then, when it evaporates, the drops fall down from the stretch film.
>
> 00.12.08 (T) Actually, our concern here was not the heat exchange between the penny and the stretch film, you know. Just, we were interested which event in the nature looks like the event you observed. By the way, it is useful to talk about the side events.
>
> (Birhan, TP-1)

Setting expectations related to students' knowledge/skills

The code refers to the teachers' instructional practices that set clear goals regarding the students' knowledge and skills. For instance, Asya, in her third lesson plan stated that

> "This step aims to provide a chance for the students to improve their writing mechanics, argument skills, and their understanding of the content. It also provides students an opportunity to engage in the writing process (i.e., the construction, evaluation, revision, and the submission of a report)." (Asya, LP-3, p.13, l. 292-296)

The teaching practices of the teachers in the typology of ML-GPK were contrasted in Table 11, presenting the occurrence of the codes for seven teachers.

4.4.7. Meta-strategic knowledge

MSK covers the general knowledge about the cognitive skills such as "making generalizations and drawing rules regarding a thinking strategy; naming the thinking strategy; explaining when, why and how such a thinking strategy should be used, when it should not be used; what are the disadvantages of not using appropriate strategies, and

Table 11 Codes for instructional strategies and occurrence of ML-GPK codes across TP and LP for seven teachers

	Can			Asya			S	M	Birhan			Mesut		
Codes for instructional strategies	1st LP	2nd TP-LP	3rd LP	1st TP-LP	2nd TP-LP	3rd LP	3rd LP	2nd LP	1st TP-LP	2nd LP	3rd LP	1st TP-LP	2nd TP	3rd LP
Naming the teaching method/strategy	*	*	*	*	*				*	*	*	*	*	
Clarifying the aim		*		*		*			*					*
Setting expectations related to students' knowledge/skills		*	*	*	*	*								
Clarifying question					*				*					
Drawing rules for a teaching method/strategy								*				*		
Providing reliable resource		*					*							
Promoting metacognitive thinking						*								
Reflection on the teaching method									*					
Revealing misconceptions					*									

what task characteristics call for the use of the strategy.” (Zohar, 2006; Zohar, 2008, p. 254; Zohar, 2012).

There were three MSK categories and codes identified in the teachers’ contributions; drawing rules for a thinking strategy (establishing causal relationships), making generalizations for a thinking strategy (making a prediction), and modelling the thinking strategy (decision making). In the following, these categories and codes were explained and exemplified in brief.

Drawing rules for a thinking strategy

The teachers fostered specific thinking strategies like *establishing causal relationships* by means of purposefully designed learning activities. For example, in her first lesson, Seher addressed how to establish relationships between different variables in a conversation with a student;

00.02.31 (S) What if I change two of them but keep one the same?
00.02.42 (T) then, if you change two at the same time, can you relate the increase or decrease as a result to just one of them? Can you say this is because of this?
00.02.51 (S) But if I need to change all, if I change all, there happens 1/8 proportion.
00.02.57 (T) Well, ok what happens if you do the same thing you do with X to others?
00.03.09 (S) we find the experimental error
00.03.10 (T) How? What should I do to find? How should be the experimental set-up?

(Seher, TP-1)

Making generalizations for a thinking strategy

Meta-strategic knowledge consists of making generalizations in addition to drawing rules regarding a thinking strategy (Zohar, 2008). This strategy was apparent in some of the lessons of the teachers in this study. For example, Birhan taught her students how to *make prediction* by making generalizations and drawing rules several times in her first teaching practice;

00.10.02 My friends, do you have a prediction?
00.10.03 Yes we do
00.10.04 What prediction is this?
00.10.05 Now, the penny will take the warm from the stretch film and therefore there will be drops here and towards the bottom they will pour-CLAIM 1

00.10.06 Is this your common prediction or do everyone has a different prediction? You may have different predictions, you may. I mean I am not saying your predictions are right or wrong right now. Write down all your ideas. I mean if you are all ok with this one, you can write this one as well. Everybody should write. You can write in your own words, it does not need to be the same word by word.

(Birhan, TP-1)

Modelling the thinking strategy

There are several components of effective pedagogical tools to develop MSK as suggested by Zohar (2006). The knowledge of how to model general thinking strategies is one of them.

In this study, in the teaching practices of some of the teachers, such modelling was apparent in the teaching of higher order thinking skills such as decision making. For instance, in his second teaching practice, Can told his students that

00.10.01 (T) as you see, in the 2nd activity 2nd question, I asked about the evidence. You wrote what made you believe there is such a problem. However, in the 3rd question, I want you to plan about how we can solve this problem; I want you to make a suggestion. If you look at the back of the paper, you will see several pictures. There are explanations about how different occupations can be affected by your suggestions. When you are making a suggestion, please take these explanations in consideration. For example, what the fisherman says that if he doesn't use sonar like devices, I can't catch enough fish and make money. He considers the economic issues related to the problem and he says he cannot sell fish for your meals. What the engineer says is that if they don't use sonar devices in exploring oil, the country doesn't have enough energy source. What the officer says is that if there are no sonar devices in battleships, they cannot save the country from enemy attacks. What I say is that how we can get out of all these. How can we both save the whales and take these people into consideration? I am waiting for your suggestions in five minutes. First have a group discussion, and then we will discuss your decisions all together.

(Can, TP-2)

The teaching practices of the teachers in the typology of ML-GPK were contrasted in Table 12, presenting the occurrence of the codes for the teachers.

In sum, the participants employed a wide range of instructional strategies to implement argumentation-based science lessons. The exploration of the instructional strategies demonstrated that in addition to the instructional strategies that were more likely to be usual such as the ones they employed in GPK and ASPK, the participants carefully and

Table 12 Codes for instructional strategies and occurrence of MSK codes across TP for the teachers

Codes for instructional strategies	Can 2nd TP	Asy 2nd TP	Seh 1st TP	Bir 1st TP	Me 2nd TP
MSK- drawing rules for a thinking strategy (establishing causal relationships)			*		
MSK- making generalizations for a thinking strategy (making a prediction)				*	
MSK- modelling the thinking strategy (decision making)	*	*			*

intentionally planned and acted in certain ways to integrate instructional strategies that were effective in initiating, promoting or sustaining argumentation. This second group of instructional strategies that were consciously brought into the lesson resulted with meta-level and meta-strategic categories of instructional strategies. This is an important outcome, because as Zohar and David (2008) pointed the explicit teaching of MSK had remarkable impact on students' learning science as an inquiry especially for low achieving students. The identification of these strategies is, therefore, significant.

4.4.8. Instructional Strategies in Lesson Plans

For the purposes of this study, the participants' lesson plans were investigated for their inclusion of instructional strategies specific to argumentation and other pedagogical knowledge. The categories and codes that specified the integration of argumentation in the lesson plans were presented in Table 13.

The table illustrated that all teachers planned to support the construction of arguments in almost all lessons by providing instructional materials such as a writing framework or other written work like hand-outs (see Appendix F for sample worksheets). Moreover, all teachers provided evidence in their activities and their lesson plans for the students' use in support of justification of their claims in the form of scientific statements, graphs, figures, or experimental data. Most of the teachers did not have any opportunity to perform an experiment or design inquiry-based activities due to the physical conditions or time limitations. Therefore, the students did not have chance to generate their own data or evidence in most of the teaching practices, that is the reason, I think, why the teachers tended to provide as much as evidence for the students' use. Considering the meta-level pedagogical knowledge specific to argumentation, table 13 indicated that all teachers

Table 13 Argument processes, codes for instructional strategies and occurrence of codes across three LP for seven teachers

	Argument Process	Codes for instructional strategies	Can			Asya			Seher			Mahmut			Hilal			Birhan			Mesut		
			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
ASPK	Constructing arguments	Uses writing frame or written work	*	*	*	*	*	*	*	*	*	*		*	*	*	*		*	*	*	*	*
	Counter arguing/ debating	Encourages debate	*														*						
	Evaluating arguments	Encourages evaluation						*									*			*		*	
	Involve more students	Address question to individual						*															
	Justifying with evidence	Checks evidence	*																				
		Prompts justification								*								*					
		Plays devil's advocate																			*	*	*
		Provides evidence	*	*	*	*	*			*	*	*	*	*		*			*		*		*
	Positioning	Values different positions		*	*									*									
ML-ASPK	Evaluating arguments	Evaluates arguments					*	*		*	*			*			*			*		*	*
		Setting expectations	*	*				*	*	*													
	Focus on debate technique	Drawing rules for a teaching method/strategy					*	*													*		
	Knowing meaning of argument	Choosing/ naming a specific strategy	*			*	*	*	*			*		*		*		*	*	*	*	*	*
		Identifies objectives / purpose				*	*	*	*		*										*		
MSK-A	Modelling the thinking strategy	Providing justification				*	*																
	Naming the thinking strategy	Constructing arguments										*											*

displayed their knowledge of strategies to implement argumentation by choosing and naming a specific strategy in almost all lesson plans they produced. On the contrary, it was difficult to identify the teachers' meta-strategic knowledge specific to argumentation in their lesson plans, although the codes in this typology were clearer to spotlight in their teaching practices.

The teachers prepared lesson plans in various topics, for grade levels between 5th grade to 11th grade, at different lengths, for varied number of students, to be implemented at schools or at exam preparation centres. These varieties in context make the comparison difficult for an individual teacher or between teachers not only for lesson plans but also for teaching practices. Therefore, at this section of the findings, I was not able to argue that the presence or the number of a code or category implies an improvement or any change based on the table. Rather, my aim was to demonstrate the instructional strategies that the teachers utilized in their lesson plans to promote argumentation.

4.4.9. Instructional Strategies in Teaching practice

For the purposes of this study, the participants' teaching practices were investigated for their use of instructional strategies specific to argumentation and other pedagogical knowledge. The categories and codes that specified the integration of argumentation in the teaching practices were presented in Table 14.

The table illustrated that the teachers in almost all lessons asked for elaboration of students' claims, arguments or justifications, prompted justification in students' argumentation, and encouraged counter arguing and debating for the consideration of alternative viewpoints. Moreover, all teachers encouraged anticipating counter-argument, evaluated the process, and valued different positions. While all teachers integrated instructional strategies in the typology of ASPK, the use of strategies in ML-ASPK and MSK-A were less apparent. For example, in only three lessons, the teachers drew rules for a teaching method/strategy, and in five lessons they modelled a thinking strategy.

In the table, the presence or the number of a code or category does not imply that the teaching was effective or not. Besides, making comparisons is difficult for an individual teacher between one lesson to another or between teachers due to the variety in contexts. Therefore, at this section of the findings, I was not able to argue that an improvement or any change based on the table. Rather, my aim was to demonstrate the instructional strategies that the teachers utilized in their teaching to promote argumentation. Nevertheless, as Simon, Erduran and Osborne (2006) argued that the presence of a code demonstrates that the teachers were attempting to teach the associated processes in the

Table 14 Argument processes, codes for instructional strategies and occurrence of codes across two TP for seven teachers

			Can		Asya		Sehe		Mah		Hilal		Birha		Mes	
	Argument Process	**Codes for instructional strategies**	1	2	1	2	1	2	1	2	1	2	1	2	1	2
ASPK	Challenge the correctness	Rephrase and address question to other group	*	*		*						*				*
		Asks for elaboration	*	*	*	*	*	*	*	*		*	*	*	*	*
	Counter arguing/ debating	Encourages debate		*		*		*	*	*		*	*		*	*
		Encourages anticipating counter-argument	*	*	*		*		*			*	*		*	
	Evaluating arguments	Evaluates process – using evidence	*			*		*	*	*	*		*	*		*
	Involve more students	Address question to individual or group		*									*	*		*
	Justifying with evidence	Checks evidence	*			*	*	*			*			*	*	
		Prompts justification	*	*	*	*	*	*	*		*	*	*	*	*	*
		Plays devil's advocate		*			*	*	*			*	*		*	*
		Provides evidence					*									
	Positioning	Values different positions					*				*	*				*
		Encourages ideas			*	*							*		*	
		Values different positions		*	*	*	*		*		*			*		*
	Reflecting on argumentation	Asks about mind-change								*						
	Talking and listening	Encourages discussion	*	*				*				*				*
		Encourages listening						*	*		*	*				

Table 14 (cont'd) Argument processes, codes for instructional strategies and occurrence of codes across two TP for seven teachers

			Can		Asya		Sehe		Mah		Hilal		Birha		Mes	
	Argument Process	**Codes for instructional strategies**	1	2	1	2	1	2	1	2	1	2	1	2	1	2
ML-ASPK	Focus on debate technique	Drawing rules for a teaching method/strategy							*		*					*
	Knowing meaning of argument	Choosing/ naming a specific strategy to implement argumentation							*							
		Identifies objectives / purpose in relation to argumentation														*
MSK-A	Drawing rules for a thinking strategy	Constructing arguments								*			*		*	
	Modelling the thinking strategy	Constructing arguments									*				*	
		Coordinating evidence		*								*				
		Providing justification	*										*	*	*	*
	Naming the thinking strategy	Constructing arguments		*									*			

students' argumentation. For instance, the presence of a code such as 'encouraged counter-argument' indicates that the teacher thought that this process is an important one in students' argumentation and should be promoted.

4.4.10. Reflections

As part of the graduate course, the participants were asked to reflect upon their teaching and their learning. A week after their argumentation teaching practices in schools, they brought the video records to the course for self-reflection as well as for peer and expert feedback. Following their argumentation teaching practices, they also submitted a written self-reflection in relation to their experiences. In this section, I presented the teachers' reflections on their teaching practices to answer the second research question and associated sub-questions, which were that

> How were the theory and practice gaps revealed with regard to argumentation in science education?
>
> > How was the science teachers' theory-practice gap revealed in the experiences of the science teachers enrolled in the graduate course?
> >
> > How do science teachers' understandings of pedagogy of argumentation change over the graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning?

To begin with, in Can's self-reflection (SR) and peer-feedback session, he mentioned about the planning of evidence cards. He stated that the evidence cards in activities should be prepared in relation to the objectives or the main concepts that the teacher would aim to teach;

> "The students were not able to make connections between the particle nature of matter and the convection and the transfer of heat. …That might be because of the evidence cards. They were not in the same standards. For example, in the evidence cards that they chose such as 7^{th}, 8^{th} or 10^{th} evidence cards, there were basic theories explaining the phenomena. This structure led the students to give priority to these evidence cards, I guess" (Can, SR, 36:26)

In a similar vein, Mesut also pointed out the difficulty of having multiple statements as evidence;

> "I thought that I wish I could have provided only two statements, which are in the same standards, instead of six. …The student groups had already eliminated the other options and there were two options mainly. Next time, probably, I would

provide only these two statements to simplify the argumentative task because hot responses were clear there. …I realized that the students have a more effective discussion with less data because I think that they were able to grasp the framework then." (Mesut, SR, 02:26)

In his reflection, Can also mentioned about the difficulty he experienced in managing the evaluation of students' arguments. He stated that

"In general, I had some issues regarding the management. I think that I was not able to differentiate the components of students' arguments. I was not sure whether a statement involves a backing or rebuttal. I might miss the feedback coming from the students in terms of their argumentation while I was teaching. However, the students' active participation was encouraging for me." (Can, SR, 37:23)

Asya also mentioned about the same difficulty in her teaching practices;

"…it is often difficult to see if we are doing an argumentation or a class discussion. We have to watch out for the components of an argumentation in order to be able to say that we are really doing argumentation in the class. Argumentation integrated class is hard to implement." (Asya, RP, p. 3, l.69-72)

Another point Asya reflected on was her role in the argumentation. She said that she did not interfere much with the students' argumentation in her first lesson. However, after she observed how I acted actively to promote their argumentation in the activities they engaged in the course, she decided to be more actively involved for encouraging argumentation in her second lesson;

"This time I was more involved in the students' argumentation based on my observations of you, of how you manage the discussion in our class. I was involved by asking questions rather than providing answers. I think that this was more educative one for me and also I think I have mastered how to manage with argumentation this time" (Asya, SR, 14:20)

However, the peer-feedback was favoured her first teaching because the others were thinking that there is a need in science classes to change the social authority and to promote student interaction although the teachers' questions enhance higher-order thinking. In her reflection paper, Asya agreed;

"In my class, I found out that I behaved as the authority instead of leaving the students to have the argumentation on their own. It was not like that in my first lesson implementation. I just left the students have an open argumentation without any of my interference. I understood with this second lesson plan that I should have been done the same thing in my second lesson too so that the students could have had more communication among themselves and also reached the conclusions that I wanted them to reach at the end. However, …Here, I admit that I was worried a little bit for not being able to have the students end up with the correct conclusion in 40 minutes which is the one class time that was given to me to have this class." (Asya, RP, p. 2, l. 44-54)

In terms of the difficulties the teachers experienced, Mesut suggested that

"I think that parts of the lesson might be designed as argumentation-based. This is more advantageous for me as a teacher because the students need a mid-platform to shift their framework. I mean that the shift from a traditional or more conventional frame to a social-constructivist frame is not easy neither for the students nor for me. There is a cognitive confliction. Therefore, I think that having a warm-up, a mid-platform is always necessary. This would end the chaotic transfer in the meantime of paradigmatic shifts." (Mesut, SR, 20:08)

In overall, the teachers were positive to the argumentation approach and the shifts in their epistemologies during the course were evident in their statements. For example, Seher wrote in her reflection paper that

"I think it was a good experience. The students in the class …were unfamiliar with this process (both argumentation and SWH), they had so many questions on the lesson plan and as they are used to see me as an authority they were not comfortable about having the authority of the lesson. They always forced me to give the right answers as usual and wanted to get approval about their opinions from me. They even told me before the lesson to give them the right answers before the lesson so they can be seen as good performers on the video. I explained them that this is the contrary of the lesson plan and I don't expect them to give right answers. I also added that, there are not right answers on this process. It is important that they think critically, think on the subject, make claims and support their ideas as much as they can. This would make our lesson better." (Seher, RP, p. 1, l. 2-12)

Similarly, Birhan indicated in her self-reflection that

"Since we were educated in our undergraduate program with constructivist approach, we have already been teaching in such a way. I am not giving the right answer; rather the students discover the concepts by themselves. …However, I have realized that now I am tended to integrate such components that will lead to argumentation into my preparation." (Birhan, SR)

Mahmut's self-reflection also indicated the shift in his understanding of science teaching;

> "I was thinking that the purpose of teaching is to teach the subject, or to let the students gain knowledge. As long as the students develop their cognitive skills and change their behaviours in the same line, I was thinking that the learning occurs. However, in argumentation, the aim is completely different. …To convince the opponent, and to inquire, to question are the priority." (Mahmut, SR, 16:58)

In conclusion, the teachers pointed out that theoretical knowledge does not always resulted with effective implementation. The teaching practices, therefore, were invaluable to experience the theory-practice overlap. As an example, the teachers stated that

> "Overall, the theory and practice do not always go together. However, we could improve the lesson plans by using the feedbacks that we have as a result of implementing the lesson plans." (Asya, RP, p. 4, l. 76-77)

> "According to me, talking about only the theory may sometimes misleads us that there may be some differences in the real classroom environments. That's why; a classroom experience was a big chance for me to see the difficulties in the implementation. Most of the time there were not a problematic issue in the lesson preparation process but in classroom environment I encountered different types of questions and I even got excited while I was facilitating the classroom." (Hilal, RP, p. 1, l. 3-8)

4.5. Discussion

In this chapter, my aims were to explore the instructional strategies employed by the teachers in their argumentation-based teaching and to describe the shift in the participants' views of their teaching practices and their associated learning throughout the graduate course. For this purpose, I investigated the lesson plans, teaching practices, and the teachers' self-reflections on their teaching. The investigation resulted with several codes and categories illustrating the instructional strategies that the teachers used as well as the participants' perceptions of their change. Here, in this section, I discussed the findings and drew conclusions regarding the teachers' experiences.

To begin with, all the teachers designed an argumentation-based lesson plan prior to their teaching practice. Yet, in some cases, there was respectively less time that can be addressed as argumentation in the classrooms. There were several reasons for not being able to enact an argumentation-based science teaching throughout the lesson. First of all, as Can said that most of the teachers met with the students for the first time and for only twice. This was highly restrictive for the teachers because knowledge of learners and learning is a critical component of pedagogical knowledge (Morine-Dershimer & Kent, 1999). Research indicate that the students' understanding of the purpose of the tasks, their individual and interpersonal learning goals, the interactions in group, especially in the case of small-group discussions, their background that they are able to relate with the issue in debate, and the classroom norms for interaction among students and between teacher and students were to be considered in the pedagogical enactment of argumentation in support for science learning (McDonald & Kelly, 2012). In the case of most of the teachers in this study, this knowledge was not accessible when they entered the classroom.

Secondly, as all teachers pointed out those students were not familiar to practices that require them to socially construct knowledge in interaction with their peers, or to prioritize evidence-based reasoning. Therefore, the teachers were also feeling the responsibility to shift the epistemic authority in the classroom, which was hardly possible in two lessons. As Walker and Sampson (2013) proposed that for the argumentation to take place, in addition to other contextual requirements, the students should be more comfortable with at least similar type of interactions, and the evaluation and critique should already be at the centre of learning environment. This was only possible with multiple experiences of participation in argumentative tasks before the students get used to the practice. Indeed, Hilal stated that because the students she studied with were already acquainted with the argumentation practices in their science lessons, enacting an argumentation-based lesson plan was not as much demanding for her in comparison to the other teachers' experiences. She also indicated that the quality of the students' arguments in her classes was relatively high compared to the videos of the other teachers.

On the other hand, although an 'ideal' argumentation did not take place, there were ample opportunities for the students to engage in scientific construction of knowledge claims. As McDonald and Kelly (2012) indicated that in the complexity of classroom interactions, despite the final form of argumentation with all its components like evidence, rebuttals, etc. was not apparent, the talk occurring still is a great deal of productive scientific interaction. Therefore, the teachers' experiences were highly valuable not only for their pedagogical expertise but also for the students who encountered such a teaching practice, even if the focus of much of the discourse was not argumentation.

In the teaching practices of the teachers and in their reflections, the teachers' great effort was apparent to transform their theoretical knowledge to an effective practice. On the other hand, the findings of the study as provided in tables in this chapter demonstrated that the instructional practices of the teachers were varied with some common practices between teachers but quite consistent in one teacher's teaching practice. In other words, the differences in the instructional practices between two teaching sessions for one teacher were much smaller than differences between teachers. Simon, Erduran and Osborne (2006) reported similar findings in their study, such that the TAP profiles generated for the teachers illustrated a consistent pattern for a teacher from one year to next while the differences between teachers were more obvious. The conclusion that was drawn from this finding was that the theoretical knowledge was transformed into a pedagogical knowledge in a unique way for each teacher. This was supported by other studies that revealed the variety in the teachers' learning progression in the outcomes of the professional development programs (Harland & Kinder, 1997; McNeill & Krajcik, 2008; Shulman & Shulman, 2004; Simon, Erduran, & Osborne, 2006).

4.5.1. Conclusions

There were two main questions that the study described in this chapter investigated. The first one was about the instructional strategies that science teachers and future teacher educators make use of in the planning and classroom practices to implement argumentation over the graduate course. I paid attention particularly to the instructional strategies of teachers because the disciplinary practices are an important aspect of teachers' pedagogical knowledge (Davis & Krajcik, 2005), and for argumentation, it requires more than the knowledge of scientific argumentation (McNeill & Knight, 2013). Since the knowledge of strategies or the theory does not ensure the transfer of these strategies into classroom practice, teachers also need to experience the ways to engage the students in the practices of science including argumentation (Davis & Krajcik, 2005).

With reference to McNeill and Knight (2013), the teachers who have an expertise in argumentation need to be competent in some other strategies, which might require a better concentration on students' actions and interactions. These strategies were apparent more or less in the teachers' practices in schools. For example, they were able to identify and evaluate the quality of students' arguments in the worksheets or during the talking; they could assess whether students integrate empirical evidence in support of their claims (McNeill & Pimentel, 2010); they encouraged students to elaborate their arguments by means of employing more evidences and considering alternative viewpoints (Simon, Erduran, & Osborne, 2006); they designed argumentative learning tasks by using specific instructional strategies, such as constructing open-ended, ill-structured cases or questions that fosters the multiple viewpoints (Berland & Hammer, 2012; Berland & McNeill, 2010; Berland & Reiser, 2009); and they tried to set a classroom environment where students listen to their peers, argue and question ideas in a persuasive discourse (McNeill & Knight, 2013). Moreover, the lesson videos of teaching practices demonstrated that the teachers were able to model argumentation when the students had difficulty to justify their claims by providing arguments or counter-arguments (McNeill, 2009). In conclusion, based on the findings of this study, I can argue that through a cycle of reflective practice the teachers adapted and developed instructional strategies to promote argumentation in their teaching practice.

The second question addressed in this study was related with the theory and practice gaps revealed with regard to argumentation in science education. The question specifically directed to understand the science teachers' theory-practice gap that was revealed in the experiences of the science teachers enrolled in the graduate course and the change in the science teachers' understanding of pedagogy of argumentation over the graduate course. Research shows that professional development opportunities can support teachers in their teaching practices to successfully integrate the pedagogical skills into their classrooms (Borko, 2004; Jeanpierre, Oberhauser, & Freeman, 2005). Likewise, in this study, the graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning provided the theoretical background for the science teachers in argumentation theory and created opportunities for the science teachers to practice argumentation in science classes. At the end of the graduate course, the teachers' self-reflections and reflection papers revealed that the transfer of theoretical knowledge of argumentation into the design and implementation of argumentative learning tasks was challenging for teachers because of the reasons discussed. Therefore, the findings of this study supported the argument by McNeill and Knight (2013), who stated that the teachers need more opportunities, more feedback and scaffolding, as well as more resources and tools to assist them in their integration of argumentation into their classroom practice.

4.5.2. Implications

The results of this study provided a detailed coding framework for the exploration of science teachers' instructional practices while they are implementing argumentation-based lessons. The coding framework may help researchers to understand the elements of argumentation that the teachers had difficulty in integrating to their teaching and in promoting students' argumentation. Furthermore, the presence of the instructional strategies coded in teachers' practice may help the researchers to find out which skills or competencies were prioritized by the teachers during argumentation. This information might be helpful for professional developers or teacher educators to decide the content of a professional development. For example, teachers may not put emphasis on the consideration of alternative ideas in students' argumentation because they may have difficulty in managing with alternative viewpoints, or they may have a positivistic approach to scientific knowledge, which assumes the existence of a truth, or they may simply be ignorant of the multiple viewpoints and focus on the expected responses. This information can be drawn from the data generated through the coding of teachers' instruction. In such a case, the professional developers might like to support teachers in these aspects of the argumentation.

This research was also helpful to understand how teachers' knowledge of argumentation have found place in teachers' practices. The results of the study implied that the teaching practices are significant for the teachers' learning. The theoretical knowledge needs to be supported with in-classroom experiences regardless of the level of theoretical background. In this study, the teachers had a meta-level understanding of argumentation through a graduate course, which comprises many activities that the teachers experienced directly and so many readings that presented theoretical and research background and supported with meta-level discussions with experts and other master and doctorate students. However, the shift in the teachers' understanding of science teaching and argumentation had been greatly influenced by their teaching practices. Thus, from this perspective, this study has implications for the teachers' learning not only in graduate courses and professional development but also in teacher education programs.

From the research perspective, another implication is related with the data that could be generated by paying attention to the voice of teachers. As I indicated at the beginning of the study, teachers' knowledge and views about argumentation and its practice in science education are crucial to the enactment of argumentation components in the curriculum, integration of argumentation as an instructional approach, or designing learning environments that foster argumentation (Sampson & Blanchard, 2012). In understanding teachers' perspective and perceptions of their learning and teaching, the data generated through the self-reflections, discussions, peer-feedback and written reflections were invaluable for this research. In multiple ways, the teachers talked about the struggles they experienced, their views about the theory-practice compatibility, and the value they attributed to the argumentation in science education. This information was used to shape the final design solution. Moreover, it was helpful in the coding of the teachers' teaching practices because while generating the codes, knowing the teachers' perspective enhances the researchers' understanding of the context, which has a great importance for research. Furthermore, their views were important because the teachers in this study represent a special group due to the characteristics they had such as being a graduate student and having a meta-level understanding of argumentation. Therefore, their practices as well as their views were an indicator of the extent to which the propositions of the educational research on argumentation were transferrable or applicable into the practice within the limitations of this study. Thus, the researchers' approach to the data generation by giving place to the teachers' voice by means of alternative opportunities to reflect can be an effective strategy in research.

4.5.3. Limitations and Suggestions for Further Research

First of all, this study was limited to seven science teachers and these teachers were composing a unique group in terms of several characteristics such as being graduate students, having a background in different disciplines, being a self-selected group (that is, they were free to be enrolled in the course, it was up to their willing), being employed in universities, schools or private institutes for exam preparation, or being unemployed. Although interpretive research orientation did not assume the generalization as a limitation, the researchers may be curious whether these instructional strategies can be located in other teachers' practices. Therefore, I explicated the characteristics of the group that I studied with as well as the research process in detail so that the researchers may have an idea how comparable these groups of teachers with other cases. Still, I may suggest the researchers to explore whether there are similar strategies for other teachers to understand the variety in teachers' actions and the uniqueness of their learning.

Another limitation is related with the data sources. Regardless of the variety or the large number of data sources, I still had difficulty at some parts of my research such as deciding the teachers' intention for an action during the coding of the teaching practices. Therefore, I may suggest the researchers who will study with the teachers to ask for participant review in coding of teachers' actions or to conduct further interviews to learn what was really in teachers' minds while responding to a student or acting in a specific way.

The other limitation of the study is the link between the teachers' practices and student outcomes. In this research, my focus as a researcher was to help teachers share the value of argumentation in teaching science, have a desire to change their current practices, have opportunities for action, share their experiences with a community of practice, reflect in order to understand the emerging patterns of change, and extend their knowledge and experience about the argumentation in science through a continuous professional support in a graduate course. However, I did not attempt to explore the students' argumentation or their experiences in regard to argumentation as a result of teachers' instructional practices. Therefore, this study might be extended further to see the effects of the final design solution on students' outcomes.

CHAPTER 5

TEACHING ARGUMENTATION TO SCIENCE TEACHERS

This chapter describes my experiences in the area of argumentation research and teaching with the purpose of unfolding the theory-practice gap from my perspective as a researcher. This part of the study is an analytic auto-ethnography with a critical self-observation and reflexive investigation in the content of a graduate course about argumentation.

5.1. Introduction

An important task in this research was to design and implement a graduate course that will help science teachers have an understanding of argumentation as a theory, share the value of argumentation in teaching science and students' learning, have opportunities for transferring their theoretical understanding into action, and create a community of learners to share and reflect upon their learning and experiences. While the course on argumentation was intended of providing such a professional development for the enrolled science teachers and future teacher educators, I, as a researcher and a facilitator experienced changes in my understanding and values related to science education as well as argumentation in science education. This change in researcher's theoretical commitments and value systems should be considered as usual since as Packer (2011) states that "When we understand another person, we don't merely find answers to our questions about them (let alone test our theories about them) but are challenged by our encounter with them. We learn, we are changed, we mature" (p. 5). Therefore, in this chapter, I provided a self-reflexive auto-ethnography to illustrate my learning process during this research.

In the graduate course, I positioned myself to act as a researcher and participant, and to observe myself as well as the participants (Schwartz-Shea & Yanow, 2012). Therefore, I felt the necessity to write an auto-ethnographical paper to illustrate my experiences during this research. In the following, analytic auto-ethnography as a research method and my role during research were explicated.

5.1.1. Purpose of the chapter

The theory and practice gap with regard to argumentation in science education was investigated in this study from two perspectives; one was the participants' perspective of to what extent their knowledge of argumentation theory that was built in the graduate course was transferable into classroom practice; and the other was to what extent I, as a researcher and facilitator, could be able to transfer my theoretical background on argumentation into my teaching argumentation to science teachers in the graduate course.

The investigation of the former one was explained in Chapter 4, p.207. For input in the later one, I examined my experiences and reflections both during research and practice through a reflexive writing. The research questions that guided the investigation were that

1. What were my experiences in the graduate course as a researcher and a facilitator designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching?
2. How was the theory-practice gap revealed in my experiences as the facilitator in the graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning?

5.1.2. Significance of the chapter

The significance of this chapter is mainly related with its methodology and analytic structure. For example, in contrast to research, which assumes the researcher as an observer without any interference with the research setting, in this study, I was in a complete member researcher status, which is being personally identified and involved in the context as a member of the social community and as a researcher. One obvious significance of this chapter in this regard is that it provides a broad description of the social world under study with an analytic reflexivity. Thus, specifically for this study, the chapter provides a facilitator and researchers' perspective, which is very rare in research on professional development on argumentation.

In terms of analytic structure, the auto ethnography in this chapter offers the researchers to pursue the connections between my theoretical commitments and social structure in the graduate course that I am involved in to design and evaluate. In other words, the analysis reported in this chapter is an iterative exploration of (1) how my theoretical commitments and background in relation to argumentation helped to constitute the sociocultural context in the graduate course and (2) how my perceptions and personal experiences were constituted by this context and social understandings. In this regard, the chapter is significant in providing the researchers an opportunity to explore the analytic perspective in terms of the interplay between a researchers' self-knowledge and the sociocultural context.

5.2. Analytic Auto-Ethnography

Auto-ethnography is defined as a form or method of research that illustrates the researcher's personal experience along with wider cultural, political, and social meanings and understandings (Maréchal, 2010). As a method, auto-ethnography combines tenets of autobiography and ethnography. What is different for auto ethnography is that auto ethnographers must critically consider about their experiences and make connections to cultural experiences with the intention of providing readers with the various aspects of culture, which could be meaningful for research (Ellis, 2004). There are different forms of auto ethnography based on the extent to which emphasis placed on the researcher' self, others, and their interactions as well as the traditional analysis, the context of the interview, and power relationships (Ellis, Adams, & Bochner, 2011).

Ellingson and Ellis (2008) indicated that two types of auto ethnography have been proposed by auto ethnographers: analytic auto ethnography and evocative auto ethnography. While the focus of analytic auto-ethnographers is on contributing to theoretical understanding of a phenomenon, evocative auto-ethnographers focus on presentations as narrative conversations and emotional responses (p. 445).

Here in this chapter, I followed the genre defined by Anderson (2006) as analytic auto ethnography. Anderson (2006) defined distinctive feature of analytic social science as using empirical data in order to comprehend broader set of social phenomena (p. 387). He characterizes the analytic auto ethnography in which the researcher is "(1) a full member in the research group or setting, (2) visible as such a member in the researcher's published texts, and (3) committed to an analytic research agenda focused on improving theoretical understandings of broader social phenomena" (Anderson, 2006, p. 375). This definition encompasses key features, such as the researcher being a complete member of the social context where the research takes place in, analytic reflexivity in writing, visibility of the researcher's self in narrative texts and in any publishing, the communication of the researcher with informants beyond the self, and the researcher's commitment to contributing to the theory of the social phenomena under investigation. In such a way, I acted as a part of the community of learners as well as the primary instrument of data collection and analysis.

In auto-ethnographies, the researcher does not report out of research with the purpose of being objective. On the contrary, auto ethnography emphasizes the researcher's unique position within a shared social and historical perspective in relation to the topic of study. In this regard, personal experience is considered to be a knowledge source (Struthers, 2012). Ellis et al. (2011) state that

> "Auto ethnography is an approach to research and writing that seeks to describe and systematically analyse (graphy) personal experiences (auto) in order to understand cultural experiences (ethno). This approach challenges canonical ways of doing research and representing others and treats research as a political, socially just and socially conscious act. The researcher uses tenets of autobiography and ethnography to do and write auto ethnography. Thus, as a method auto ethnography is both process and product." (p.1)

It is not an easy task to relate or evaluate the personal experiences in a wider social context. To be able to analyse the self beyond the boundaries of a personal life, Anderson (2006) claims that the researcher must be a member or a subject of the community through personal experience. This membership status should be made explicit by sharing the social context on and around the research theme of the analytic auto ethnography (Struthers, 2012). The membership status is a reference to the emic perspective, which describes the researcher as an insider and values the personal experience as a legitimate knowledge source (Struthers, 2012). The underlying assumption is that regardless the commonalities they have and sharing the same community membership, the experiences of two individuals are likely to be different (Buzard, 2003). Moreover, one identity can be characterized by being a member of different communities. For instance, my own professional identity, which is a combination of my gender as being female, my academic status as a research assistant, and my profession as a teacher, creates my unique worldview. Therefore, I agree with Struthers (2012) that "membership criteria should recognise the differences which sustain world views rather than confirm similarities" (p.23) in analytic auto ethnography from a qualitative interpretive perspective.

Another key feature of analytic auto ethnography is its commitment to analytic reflexivity. Anderson (2006) described analytic reflexivity such that

> "At a deeper level, reflexivity involves an awareness of reciprocal influence between ethnographers and their settings and informants. It entails self-conscious introspection guided by a desire to better understand both self and others through examining one's actions and perceptions in reference to and dialogue with those of others" (p.382).

The auto ethnographers claim that analytic reflexivity provides researchers with opportunity to identify which processes results with their understanding of phenomena

(Collyer, 2011). In analytic auto ethnography, analytic reflexivity is a way to gain an insider's perspective (Struthers, 2012). Struthers (2012) asserts that the insider's perspective is critical to refine the theoretical insight into the social processes.

The third feature of analytic auto ethnography is visibility of the researcher's self in narrative texts and in any publishing. The visibility refers to the inclusion of data regarding the researcher's own experiences and cognitive development in order to ensure the researcher's visibility as a member of the social context (Anderson, 2006). However, as Anderson (2006) stresses the researcher is required to maintain balance between self-analysis and analysis of social interactions. A data generation method to visibility within a narrative is the self-reflection of the researcher (Struthers, 2012).

The communication of the researcher with informants beyond the self is as much important to ensure the avoidance from the solipsism or self-absorption (Anderson, 2006). Struthers (2012) maintains that the interactions with the others along with the ethnographic reflexivity contribute to the exploration of the relationships which enables the construction of the social world under study. Anderson (2006) points out this feature such that

> "The auto ethnographer is a more analytic and self-conscious participant in the conversation than is the typical group member, who may seldom take a particularly abstract or introspective orientation to the conversation and activities. But the auto ethnographer's understandings, both as a member and as a researcher, emerge not from detached discovery but from engaged dialogue." (p. 382)

In other words, analytic auto ethnography is a practice of linking the researcher's perspective and experiences with the other participants' perspectives (Struthers, 2012). For example, in his PhD dissertation, Brown (2006) investigated the ways through which four high school teachers construct their professional identities personally and socially. He employed auto ethnography as a method and involved himself as one of the participants. While doing so, he interviewed with each teacher to explore the dynamics of identity in their teacher-selves combined with his auto ethnography (Brown, 2006).

The last feature of analytic auto ethnography was stated to be commitment to analytic agenda. Being analytic in term here means to seek insights to contribute to the theoretical practices rather than the methodological analysis of data. The purpose is to move from the methodological stage to draw implications from data that may inform the social world by being related to theoretical background. Struthers (2012) added that "adherence to theoretical analysis causes the researcher to disseminate their own insights and findings to inform the policy and practice of others." (p.59). Thus, as long as the theoretical commitments are pursued, the analysis of the researcher's own perspective transcends the boundaries of self to inform the practice of others.

In this part of my investigation, therefore, I followed the key features of analytic auto ethnography in order to contribute to the understanding regarding the teachers' professional development in argumentation.

5.2.1. Data Generation

In this research, my dual roles as the researcher and the teacher enabled me to gain access to the empirical data sources regarding my role and to better able to comprehend the implications of my role. Besides relying on the evocative aspects of my experiences, I generated empirical data from various sources that are;

Self-observational / self-reflective records;

Self-observational or self-reflective records are useful data sources because the researcher's personal experiences including cognitive and affective processes, masked or eliminated actions, and socially normative activities can be accessed through these records (Rodriguez & Ryave, 2002). Chang (2008) argued that self-observation can be in the form of self-introspection or "interactive introspection" depending on whether the researcher is alone or with others. In the case of auto ethnography, "systematic self-observation" is suggested by Chang as the researcher focuses on self as informant. The researcher may use field texts or self-recording to document unstructured or structured self-observation (Chang, 2008).

In this chapter, I used the classroom video-records as a source to my interactive self-observation with others. I reported my personal values and preferences in relation to my cultural identity and cultural membership. Moreover, I searched the participants' reflections in their reflection papers and post-interview to discover myself through the lenses of others.

External data

External data was described as data generated through the dialogical exchange with other colleagues in practice field (Struthers, 2012). The participant observer, as it was termed in this study, was not involved in the data generation but she was a data source as well. In this regard, I made use of the dialogues we had with the participant observer in the form of audio recorded formal meetings and irregular meetings since she was a colleague.

Clinical supervision

Clinical supervision is another data source that was suggested by Struthers (2012). The meetings with my supervisor summarising and discussing the key issues in the graduate course were held several times during the development of educational design solution. These meetings were audio recorded to be used as a data source.

5.2.2. Trustworthiness

I adapted the reliability and validity criteria that were employed by Struthers (2012) in his study where he used analytic auto ethnography to develop the use of self when teaching mental health nursing. The researcher utilized Guba and Lincoln's (1989, cited in Struthers, 2012, p.79) criteria of 'ontological authenticity', 'educative authenticity' and 'catalytic authenticity' along with the criteria for fairness to ensure trustworthiness in his auto ethnography. The same approach was adopted in this study.

Fairness

Fairness is addressed when the researcher conducted the study in such a way that s/he ensures the confidentiality of the participants' and their responses (Manning, 2000). For example, in this study, consents given by the participants prior to the pre-interviews and explanation of the purpose of the study prior to the interview were techniques to ensure fairness.

Ontological authenticity

The researcher matures during the study, but through the activities of ontological authenticity, the researcher's awareness and consciousness are raised (Manning, 2000). One way to achieve ontological authenticity is, as Tobin (2006) suggests, reporting the alteration in the perceptions in relation to the nature of social world under study, as it pertains to the research foci. Thus, I examined and documented the changes that occur in my theoretical understanding of study and the associated changes in the methodology.

Educative authenticity

Educative authenticity refers to understanding and appreciating the constructions and values of others related to the area of study (Schaller & Tobin, 1998). In this study, educative authenticity was ensured by asking others to verify my understanding of their interview data (Nowacek, 2008), clinical supervision to focus on my reflexivity as subject (Struthers, 2012), and discussing the research results with the participants during the writing of the dissertation.

Catalytic authenticity

Catalytic authenticity is concerned with the need for action on the part of the other participants within the context of the research (Schaller & Tobin, 1998). To achieve catalytic authenticity, in the implications section of this chapter, I explicated how the insights and findings as a result of this research may be disseminated for the policy and practice decisions to inform educational practices.

5.3. Teaching Argumentation to Science Teachers

The course on argumentation was a product of educational design research, in which development of solutions to practical and complex educational problems provides context for empirical investigation, which yields theoretical understanding (McKenney & Reeves, 2012). In this process, the first goal was identifying or conceptualizing the problem. These goals were addressed through literature review and pre-interviews. Literature review helped me to gain insight to both the theoretical inputs to understand the problem and practical aspects such as the data collection and analysis procedures that I would use to frame the research. Pre-interviews provided me with the teachers' viewpoint in terms of the integration of argumentation or any discourse-since they were not familiar to the argumentation before the design of the course addressing argumentation and their perceptions of any problems accompanying with the implementation of discourse in their classrooms. The second goal was constructing a richer understanding of the problem as well as the attempts to solve it. I attended to the research conferences, I paid visits to the professionals working on the problem or contacted with them via e-mail, and I argued about my proposal with my dissertation examining committee in biannual meetings. These interactions helped me to identify the design requirements that relate to the problem, setting, and participants of this study. With the aim of constructing an educational design, I collected a set of design solutions that were constructed and implemented by other researchers for long periods. The design process served as a guide for me to construct an initial design proposition. All these phases and the implementation process have altered my views and beliefs related to science education and argumentation in science education. In the following, I will explicate all these and discuss the possible implications to inform educational research.

5.3.1. As a researcher

My initial orientation to studying argumentation goes back to 2007. I wrote a master's thesis about the nature of pre-service science teachers' argumentation in inquiry-oriented laboratory context (Ozdem, 2009). My point of discussion was that although research show evidence to the effectiveness of argumentation as an instructional approach and educational goal for science education, the studies pointed out to the lack of argumentation opportunities in science classrooms (Grandy & Duschl, 2007; Osborne, Erduran, & Simon, 2004). The main argument for the lack of argumentation practices in schools was that teachers or curriculum are ineffective or inadequate in reflecting the aspects of argumentation found in professional scientific practice (Bricker & Bell, 2008). Despite the recent emphasis on professional development programs designed to improve the teachers' argumentation-based instruction, these efforts remain restricted to a small population of teachers and the issue continues to be in the research agenda (Sampson & Blanchard, 2012).

Hence, I proposed that if science teachers are trained in argumentation practices similar to professional scientists', argumentation will be more widely integrated into science classrooms. The results were promising in terms of demonstrating pre-service science teachers' engagement in argumentation during laboratory work (Ozdem, Ertepinar, Cakiroglu, & Erduran, 2013). Moreover, this study was an incentive for me to support pre-service science teachers in their use of arguments because, as Zohar (2008) indicated, I believed that teachers must be able to engage in high quality argumentation themselves before they can support students' successful argumentation. However, I realized that teachers' learning and teaching argumentation require more structured professional development opportunities (Hoban, 2002; S-TEAM, 2010).

Nevertheless, in my presentations and discussions, I have always faced with the same question: whether pre-service science teachers' experiences will be reflected in their future science classrooms (My presentation at the University of Bristol, Spring-2009). The answer is complex because teachers' learning has many facets: To begin with, teachers need to share the values of the argumentation as a new motive and be prepared to take threats (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010). They should have a desire to change their current practices, have opportunities for action, share their experiences with a community of practice, reflect in order to understand the emerging patterns of change, extend their knowledge and experience; and finally need to have time to adjust to the changes made through a continuous professional support (Hoban, 2002). Moreover, it takes significant time to begin to use new instructional practices in a competent manner, and teachers should be supported with continuous reflection and feedback in order to feel self-confident to introduce new practices, like argumentation, in their classrooms (Clarke & Hollingsworth, 2002; Zohar, 2008).

Meanwhile, in the conferences and meetings I participated, I had conversations with teachers and researchers; and I witnessed to the attempts to develop continuous professional development programs for in-service teachers. One of these programs, which was presented at the European Science Education Research Association Conference in 2011, initiated by Osborne, Simon, Christodoulou, Howell-Richardson, and Richardson (2011). In their presentation, Osborne and Simon described the purpose of their study as to investigate “whether a cycle of collaborative reflective professional development involving distributed leadership would enable science teachers in a department to develop a pedagogic practice that made greater use of argumentation in their teaching” with whole school science departments. Their interest was on what kind of gains in teacher practice and student learning could be achieved with such an approach to teacher professional development. After listening to their presentation, I wrote to the researches to ask for their full paper, titled as that "Developing the teaching of argumentation and its effect on student outcomes" which they presented on Wednesday, September 7th (E-Mail to Jonathan Osborne, 10.09.2011). The paper that Jonathan Osborne sent to me the next day had important frameworks for my understanding of teacher education that I had not realized even at that time.

I was assuming that the teachers’ learning is not different than the students’ learning. Moreover, I believed that the teachers’ learning is a linear process, and teachers’ in classroom activities mostly related with the pedagogical knowledge that they have. In the paper, which Osborne sent to me, there was a completely different image of teacher learning proposed by the following sentences;

> “Transforming pedagogy requires teachers to share the values of an innovation and be prepared to take risks (Claxton, 1988; Loucks-Horsley, Hewson, Love, & Stiles, 2003) – a venture that is best supported by establishing the practice of collaborative reflection within a community of professional learning (Hoban, 2002). Early approaches to teacher development that had little sustained impact were underpinned by mistaken beliefs that teacher learning is a linear process where teachers’ practice could be transformed by prescriptive approaches, whereas current knowledge would suggest that a more complex view of professional learning is required to bring about sustained change (Desimone, 2009).” (Osborne, Simon, Christodoulou, Howell-Richardson, & Richardson, 2011, p. 7)

After the Osborne’s paper, I understood that I had those mistaken beliefs that Osborne pointed out, and I had a lack of knowledge in the area of ‘how teachers learn’. My lack of knowledge in this area was also clear in my initial attempts to design a professional development program, and that was the reason that my dissertation committee members suggested me to learn more about the teachers’ learning. The review of the research on teacher learning introduced me to the idea of transformational teacher learning. At the end, the model of teacher professional development that I adopted in this study was what

Kennedy (2005) represents as the transformative model. According to the model, the theoretical background and research should be presented to teachers and then they should be invited to ‘explore’ how those ideas might be ‘translated’ into their classroom practice. Called also as transformational or transformative learning, in this model, teacher empathy with project aims and teacher motivation to engage with ideas through reading and discussion were fundamental for teacher learning.

The idea to enhance the teachers’ use of argumentation in science classroom was my main purpose but the achievement of this purpose was more demanding than I thought. There were issues regarding the recruitment of science teachers and communication with them for the possible outcomes of the draft program. I contacted with the Department of In-service Teacher Training, at Ministry of Education, in Turkey. However, the involvement of teachers was only possible through a funded professional development project, or I needed to seek for individual volunteers who were able to devote after school time for such projects. Thus, the recruitment of teachers was a major problem because the professional development program I proposed was neither a part of a nation-wide project nor there was financial support to conduct after-school professional development program because such a program would at least require a centre to study.

Moreover, I was involved in a project called LD-Skills, which was funded by the European Commission, aimed “to capture a variety of pedagogical models (inquiry-based and problem-based learning) for facilitating the process of strengthening students’ key competencies”, and this was to be achieved “through the development, implementation and test of a training framework that will provide a means for creating learning activities into a workflow, capture a wide variety of pedagogical models and, and provide a vehicle for the sharing and re-use of learning design patterns in schools” (The LD-Skills vision: Objectives, 2013). My hypothetical idea was that learning design system would provide assistance to science teachers in designing argumentation-based science lessons. My proposal was that learning design is a sustainable, long-term and open-to-development system that will assist teachers to adapt and be familiar to new instructional theories, models and designs (Duschl, 1990). Moreover, as suggested by Yan and Erduran (2008), argumentation can be taught through suitable instruction, task structuring and modelling through tools generated through information and communication technology (ICT). Therefore, as a product component of the teachers’ professional development, I planned learning design software that would aid teachers in creating argumentation-based science lessons. However, early prototypes are not generally representative of all elements of a product solution, rather they evolve to more feasible and enduring ones (McKenney & Reeves, 2012). The mode of delivery for most of the learning designs is relevant to the use of Information and Communication Technologies (ICT), which focus on content and services (Britain, 2004). In this study, the plan was also to engage teachers in the use of computer-based Learning Design. The software for the program was designed and tested by a professional computer software programmer. However, the integration of the software into a web-based platform could not be possible because of the technical issues, which took a long-time to resolve. At the end, the product component was transformed from learning design software to a graduate course program with a collection of lesson plans and lesson videos as well as students' artefacts, which were initially planned to be integrated into the software.

Thus, I had to find ways of accessing teachers. In my research, I realized that although today, in the curriculum documents, argumentation is emphasized explicitly, there are only a few programs that offers course on argumentation for to-be science teachers, and little has been targeted post-secondary level (Walker & Sampson, 2013). Therefore, in communication with my supervisor, I decided to access teachers through a graduate course, which was a selective one.

The development of a graduate course was another endeavour for me because it was not simply deciding on the readings and/or the activities. At this point, besides the argumentation theory and what I had learned about the teachers' learning, there were more fundamental thoughts that need be identified; I had to interrogate my philosophy of education, my research paradigm, and I had to decide the most appropriate model to design a graduate course. In my deep investigation to identify my ontological and epistemological assumptions, I remember that almost each week I requested for a meeting from my advisor with questions in my mind and books on my hand to discuss whether my philosophical orientation to education can be identified as constructivist, humanist, radical constructivist, between paradigms or another orientation that I was not familiar with yet. This question was really important but difficult to answer. Why it was important was best answered by Conti (2007). First of all, Conti (2007) maintains that understanding one's philosophy and how various philosophies are practiced by others results with interactions with colleagues in a more professional rather than personal way. I experienced such debates on educational policy and philosophies with my colleagues after I was able to identify the basic philosophical differences. Secondly, Conti (2007) argued that knowledge of one's own philosophy can help her/him clarify the interrelations of one's goals and the mission of the profession that s/he practices. In the case of teaching, this knowledge of professional beliefs can help the teacher educator clarify the relations between specific field of teaching and the overall field of education. Thus, Conti (2007) concluded that the knowledge of educational philosophy can stimulate reflective thinking at various levels of professional practice. However, as Ozmon (2012) stated "Developing a thoughtful philosophical perspective on education is not an easy task. It is necessary, however, if a person wants to become a more effective professional educator" (p.5).

As much important, the philosophical orientation to research was also critical for me as a researcher. I agree with Popkewitz (1984) stating that

> "To focus solely on techniques and procedures produces certain limitations to the conduct of inquiry. First, the lack of situating concepts and techniques within their social and philosophical contexts produces knowledge that is often trivial and socially conservative. Second, the social sciences have competing traditions. To consider the various traditions as differences only in techniques is to obscure the assumptions and implications of these traditions." (p. ix)

Thus, I reviewed the research traditions to decide finally that constructivist interpretive thought is more aligned with my understanding of the purpose and approaches to educational research. My assumptions regarding the educational and social sciences are that there are multiple realities consisting of people's subjective experiences of the external world constructed through experiences and interactions with others (Denzin & Lincoln, 2005) in ontological level and because the meanings are co-constructed by individuals, there is possibility of multiplicity of meanings (Schwartz-Shea & Yanow, 2012).

Another decision as a researcher was the selection of appropriate methodology for conducting the research. The educational design research was not the first one I thought of while planning this study. Rather my focus was on argumentation theory and the learning design. Thus, I was in search of a methodology that would allow me to integrate the learning design and at the end have a product as well as that would support the research in terms of the refinement of the argumentation theory. During my literature review, the keywords I used resulted with educational design research. At the first sight, I thought it was another term used for the learning design. However, while reading the study by Gravemeijer and Cobb (2006), I realized that design research is a genre of research, through which I can develop solutions to my research questions that are practical educational problems and that seek for theoretical understanding that can inform the work of others (McKenney & Reeves, 2012). My review of research on educational design research resulted with the methodological solutions that helped me clarify my research goals, methods, data sources, and interpretation of findings as well as my preference of writing this dissertation in an unusual structure.

In terms of my understanding of argumentation, I have also made progress. I had an understanding of argumentation as a kind of discourse through which knowledge claims are constructed or evaluated. I had thoughts about the wider implications of argumentation as a culture. For example, I had been thinking argumentation also as a way to build up a democratic classroom culture, where the existence of different views are valued and respected. However, the philosophical approaches to argumentation had not been in my agenda until I realized and begun to discuss the different meanings attached to argumentation in this course. Moreover, the participants' interest on philosophical approach to science as well as the connections they made between different philosophical orientations and argumentation made me think about this issue carefully.

As Mesut pointed in the pre-interview, "We intentionally or unintentionally relate argumentation with cognitive constructivism or social constructivism". This was the case for me as well. I was thinking that argumentation is coherent with social constructivist theory of learning (See 1.5. The Philosophy of Education, p.8), yet this coherence was not unfaltering. Besides, I was unable to argue how and why the other conceptualizations of argumentation were not consistent with my view of science teaching and learning.

Therefore, with regards to argumentation, I developed insight into the philosophical underpinnings of different traditions and their articulation of argumentation as well as had a comprehensive search about the coherence between social constructivist learning theory and argumentation. I clarified my views regarding the purpose and the outcomes of integrating argumentation in science education and in wider culture throughout this research.

To sum up, as a researcher, during the long process of the development and writing of this dissertation, I clarified my position in regard to philosophy of education, research tradition, and research design in addition to my theoretical understanding of professional development on argumentation, teachers' learning and teaching, and teaching in higher education.

5.3.2. As a facilitator

My role as a facilitator was not new for me because I worked as a science teacher for almost five years in elementary schools, and I was a teaching assistant in undergraduate courses such as 'ECE-250 Basic Science for Early Childhood Education' and 'ELE-343/4 Methods of Teaching Sciences I-II' for Elementary Science Teacher Education, and in graduate courses such as 'ESME-560 Analysis of Research in Elementary Mathematics and Science Education' and 'ESME-509 Educational Inquiry'. However, my role during the course 'ELE-331 Laboratory Applications in Science I', which was laboratory instruction was critical.

The aim of the course was to help student-teachers gain the skills to successfully manage with the laboratory applications in science education. I was the facilitator of the laboratory sessions and there were other research assistants available in the laboratory studying together with the small groups of pre-service science teachers. During the laboratory work, my role was to monitor the progress of the pre-service science teachers and to support their discourse. In supporting the discourse among group members and in whole class, I asked questions, and/ or proposed counter-arguments when pre-service science teachers required going further. This was the time when I first experienced designing argumentative laboratory tasks (Ozdem, 2009) and teaching through argumentation at university level. I acted as a role model in handling the laboratory tasks but in terms of teaching argumentation, I did not give pre-service science teachers an instruction on how to teach an argumentation-based science lesson. Overall, the course was the first as being the facilitator, who designs and implements the course with all tasks, but I could say that I knew less about being a teacher educator.

One of the graduate courses was particularly helpful in this respect. 'Instruction: Theory and Research' course focused on basic instructional theories and various themes in research on instruction. During the course, theories and themes were reviewed for their approaches to teaching rather than learning. The main topics of the course were the study of teaching; teacher thinking, teacher decision making, and teacher planning; and classroom discourse and teaching as a linguistic activity. The course contributed to my understanding of the research aspect of teaching, increased my awareness of the variety of contrasting approaches to teaching, helped me develop a critical perspective into research and establish relation between instructional theories, research and their implications for practice.

Furthermore, I was involved in projects targeting teacher professional development, which added to my qualification as a teacher trainer. For example, one of these projects was PROFILES (Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science), which has been funded by FP7 (7th framework) programme of the European Commission (http://www.profiles-project.eu/index.html). One of the aims of the project was to give teachers a better appreciation of the contemporary approaches and purposes of teaching science in middle and secondary schools and the value of networking with their colleagues from 21 European countries (Bolte, et al., 2012; Rauch, Holbrook, & Bolte, 2011). The PROFILES request was to support teachers in inquiry-based science teaching through a longitudinal professional development program reflecting a range of stakeholder views and teacher needs (Rauch, Holbrook, & Bolte, 2011). In Turkey, in the project partnership of Dokuz Eylul University, I took part as one of the teacher trainers in the professional development programs. My role was twofold: the design and implementation of programs based on the perspectives of the PROFILES project (Ozdem & Cavas, 2012), and dissemination of the program results via journal articles, conference presentations, newsletters, web-page, and online social platforms (Cavas, Ozdem, Cavas, & Kesercioglu, 2012; Holbrook, Cavas, Ozdem, & Cavas, 2012).

In sum, in regard to my experience, as the facilitator of the program, in teacher training and professional development of science teachers as well as in learning design practices, the final conclusion was that I am qualified in handling these programs. My only hesitation was that the level of the group in the graduate course was higher than the levels to which I used to teach before. I was experienced in studying with professional science teachers; however, the needs and expectations of them from a graduate course could not commensurate with those from a professional development program. The content as well as the interactions and opportunities for action must be in a higher level for a graduate course. Informing a MBA level organizational behaviour graduate course, Betts (2008) argued that

> "Graduate students expect to draw on their experience and expertise to participate in high level discussions and engage in advanced applications of the course material. …The instructor's challenge is to design a course that can progress from basic concepts to advanced applications within a single semester." (p.99)

Therefore, I collected a set of design solutions that were constructed and implemented by other researchers for long periods and designed an initial design solution (see Chapter 3, p.48). The responses to the design solutions were encouraging for me as a facilitator. For example, in the post-interview Can appreciated me and the design of the course such that;

> "About you, I appreciated your efforts as well as your expertise on the subject. I think I can successfully implement argumentation in my classes but teaching argumentation is something different because I don't think that I have mastered the subject so well considering your expertise on literature, your experiences or your intellectual background. Since this is your area of study, you are far further competent than us. …The course was good and I guess that it was prepared purposefully." (Can, PI)

There were responses focused on the content of the course, such as

> "I might only say that we could talk more on our practice videos. I think that the articles were well-chosen." (Hilal, PI)

> "I very much liked the content of the course. I don't have many suggestions. Maybe I can say that the activity sheets can be published as a booklet or workbook." (Birhan, PI)

The comments from my supervisor also indicated the success of the course;

> "My previous experiences, my observation in other courses point out to the fact that the students talk less. We might be lucky that the group is good because although there are few people, they are participating. Sometimes, the number of people in the class may be more, but the talk may be less. I also think that your influence is high. I should say that you are a good teacher, I am sure of that. Even though I know what you are talking about, I like to listen to you. …I guess this is a great advantage. The participants may try to help you because they know you. This may help the debate to be more hospitable… In overall, I am satisfied with your teaching and the progress" (J.C. - feedback, 23.03.2012- 08:00).

On the other hand, there were instances that I had difficulties. For example, the backgrounds and the learning needs of the participants were significantly determinative. I realized that the 'common ground' concept is very important to plan further steps. As Betts (2008) argued that

> "However the varied backgrounds of the students frequently necessitate a review of the basic concepts in order for the class to have a common understanding and vocabulary….The primary challenge for the instructor is to move from delivery of basic knowledge to sophisticated meaningful discussion in the time span of a single semester, and the secondary challenge is to assess the steps along the way" (p.99)

In such cases, as much as possible, I facilitated discussions on the basic concepts and common understanding. However, these 'extra' discussions are very risky for the rest of the class.

My experience as a facilitator regarding one of the participants of the course, Mesut, is noteworthy to illustrate the theory and practice gap in my experiences. The reason is that Mesut was a PhD student and he had a master's thesis on argumentation like me. Thus, he had a comprehensive background on argumentation. At the beginning, it seemed like a challenge since it was likely that the course would not add anything new to his current knowledge or he might dominate the discussion during the course. However, this was not the case in general. I should admit that at the beginning of the semester, the philosophical discussions in the first week were dominated by Mesut. He made a great contribution to the course by his knowledge of the philosophy of science. However, at the same time, his contributions regarding the philosophy of science also revealed considerable gaps between Mesut and me and the other participants.

Although I was familiar to the major philosophers and their ideas, I had not been involved in any discussion regarding these views. Therefore, I was not sure to what extent I internalized these views or had critical thoughts about them. This situation was frustrating for me at first. However, my role in the class made the transition much easier. Because I assumed a role not as an authority but a complete member of the classroom culture, I shifted my understanding of being a facilitator from a leader or a guide to one of the participants learning and discussing as the others doing.

When the other participants requested further discussion regarding the points made by Mesut in the first week of the course, inevitably, the schedule of the course as well as the direction of the discussions for the coming weeks were changed; a difficult task to handle in a short time for me. Moreover, the focus of the course shifted. In this case, I was glad that there were the participant observer and my supervisor in the class. They alerted me to keep the progress on track and supported me how to turn back to the big idea of the course back (see 3.4. Evaluation and reflection, p.168).

I agree with Mansour et al. (2014), who underlined that empowering teachers could challenge the facilitators' views about effective teacher professional development and call for them to work with teachers as research partners, who have voice in their own professional development. However, I think that this was not a difficulty but an opportunity for me. Throughout the course, by means of being a part of the culture, I learned a lot from Mesut and the other participants as well, shared my understanding with others and asked for their opinions, and worked with the others as research fellows.

5.4. Conclusion

The concluding reflections in this section are constructed on my reflexivity. In the methodological processes of conducting analytic auto ethnography, I investigated to what extent I, as a researcher and facilitator, could be able to transfer my theoretical background on argumentation into my teaching argumentation to science teachers in the graduate course. In particular, I examined my experiences and reflections both during research and practice through a reflexive writing.

Throughout the process of writing analytic auto ethnography, I experienced a learning process relating to how I perceived philosophy of education, research tradition, and research design in addition to professional development on argumentation, teachers' learning and teaching, and teaching in higher education. My experiences in the graduate course as a researcher and a facilitator designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching were not limited to the pedagogical ones. I also appreciated the meta-level talks we had during the course in terms of my personal development. The construction of a community of learners, where the learning of each teacher was a unique experience, was impressing for me.

In this chapter, I also explicated the theory-practice gap revealed in my experiences as the facilitator in the graduate course designed to improve theoretical understanding and pedagogical practice in argumentation in science teaching and learning. Throughout the course, I realized my lack of knowledge and experience in many areas of teaching to teachers and teaching argumentation at meta-level. Nevertheless, the meetings with my colleagues, the participants, the participant observer, and my supervisor supported me to realize these gaps and I was eager to learn more and more. The statements made by them stressed the shortcomings of my theoretical knowledge as reported in different parts of the dissertation. However, in overall, the objectives of the course were achieved and the participating teachers and teacher educators were satisfied by the outcomes of the course as apparent in their post-interviews and post- course actions.

5.5. Implications and Suggestions

The chapter in this dissertation confirms the value of analytic auto ethnography as a research approach to develop the understanding of the researchers' and facilitators' perspective in the higher teacher education. This dissertation was one of the rare attempts to use auto ethnography especially in science education research. Therefore, the methodological strategies followed in this study might inform the other studies in this line. However, this dissertation or the chapter is not an ideal one without their shortcomings. There is need for further methodological guidance and studies in order to develop and refine the use of analytic auto ethnography in search of answers to educational problems, especially for those the researcher is also the subject of the research.

Moreover, the data presented here as my analytic auto ethnography acknowledged a range of influences on myself as a facilitator and researcher. These influences were varied, including my internal dilemmas of being a teacher educator, facilitator, and researcher. In this regard, this chapter was the unique holistic presentation of me as a subject of the research that the other researchers or teacher educators may have lessons to draw from. Finally, I, therefore, suggest further the use of analytic auto ethnography as to clarify the issues related to teaching and research from more teacher educators and educational researcher for appreciation of the complexity of others' identity and their reflexive analysis.

REFERENCES

Acar, Ö. (2008). *Argumentation skills and conceptual knowledge of undergraduate students in a physics by inquiry class.* Unpublished PhD dissertation, Ohio State University.

Adler, J. (2000). Social practice theory and mathematics teacher education: a conversation between theory and practice. *Nordic Mathematics Education Journal (NOMAD), 8*(3), 31-53.

Ahuvia, A. (2001). Traditional, interpretive, and reception based content analyses: Improving the ability of content analysis to address issues of pragmatic and theoretical concern. *Social Indicators Research, 54*(2), 139-172.

Aikenhead, G. S. (1997). A framework for reflecting on assessment and evaluation. *Globalization of Science Education: International Conference on Science Education* (pp. 195-199). Seoul, Korea: Korean Education Development Institute.

Airasian, P. W., & Walsh, M. E. (1997). Constructivist cautions. *Phi Delta Kappan*, 444-449.

Akkus, R., Gunel, M., & Hand, B. (2007). Comparing an inquiry-based approach known as the science writing heuristic to traditional science teaching practices: Are there differences? *International Journal of Science Education, 29*(14), 1745-1765.

Akpınar, Y., Ardaç, D., & Er-Amuce, N. (2014). Development and validation of an argumentation based multimedia science learning environment: Preliminary findings. *5th World Conference on Educational Sciences - WCES 2013. 116*, pp. 3848 – 3853. Elsevier Ltd.

Albe, V. (2008). When scientific knowledge, daily life experience, epistemological and social considerations intersect: Students' argumentation in group discussions on a socio-scientific issue. *Research in Science Education, 38*, 67-90.

Alsop, C. K. (2002). Home and away: Self-reflexive auto-/ethnography. *Forum: Qualitative Social Research, 3*(3).

Anderson, L. (2006). Analytic aoutoethnography. *Journal of Contemporary Ethnography, 35*(4), 373-395.

Anderson, L. (2011). Analytic auto-ethnography. In P. Atkinson, & S. Delamont (Eds.), *SAGE Qualitative Research Methods (e-book)* (pp. 297-306). Sage Publications.

Arslan, M. (2007). Constructivist approaches in education. *Ankara University, Journal of Faculty of Educational Sciences, 40*(1), 41-61.

Aslan, S. (2014). Öğrencilerin yazılı bilimsel argüman oluşturma ve değerlendirme becerilerinin incelenmesi [Analysis of students' written scientific argument generate and evaluation skills]. *Eğitimde Kuram ve Uygulama, 10*(1), 41-74.

Avraamiodou, L., & Zembal-Saul, C. (2005). Giving priority to evidence in science teaching: A first-year elementary teacher's specialized practices and knowledge. *Journal of Research in Science Teaching, 42*, 965-986.

Babbie, E. R. (2007). *The practice of social research.* Belmont, CA: Thomson Wadsworth.

Bamberg, M. (2012). Narrative Analysis. In H. Cooper (Ed.), *APA Handbook of Research Methods in Psychology* (Vol. 2, pp. 77-94). Washington, DC: APA Press.

Barreto-Espino, R., Zembal-Saul, C., & Avraamidou, L. (2014). Prospective elementary teachers' knowledge of teaching science as argument: A case study. *School Science and Mathematics, 114*(2), 53-64.

Baxter, L. A. (1993). Content analysis. In B. M. Montgomery, & S. Duck (Eds.), *Studying Interpersonal Interaction* (pp. 239-254). New York, NY: Guilford Press.

Bell, P., & Linn, M. C. (2000). Scientific arguments as learning artifacts: Designing for learning from the web with KIE. *International Journal of Science Education, 22*(8), 797-817.

Ben-Peretz, M. (2011). Teacher knowledge: What is it? How do we uncover it? What are its implications for schooling? *Teaching and Teacher Education, 27*, 3-9.

Bereiter, C. (1994). Constructivism, socioculturalism, and Popper's World 3. *Educational Researcher, 23*(7), 21-23.

Berland, L. K., & Hammer, D. (2012). Framing for scientific argumentation. *Journal of Research in Science Teaching, 49*(1), 68-94.

Berland, L. K., & McNeill, K. L. (2010). A learning progression for scientific argumentation: Understanding student work and designing supportive instructional contexts. *Science Education, 94*, 765-793.

Berland, L. K., & Reiser, B. J. (2009). Making sense of argumentation and explanation. *Science Education, 93*, 26-55.

Betts, S. C. (2008). Teaching and assessing basic concepts to advanced applications: Using Bloom's taxonomy to inform graduate course design. *Academy of Educational Leadership Journal, 12*(3), 99-106.

Billig, M. (1996). *Arguing and thinking: A rhetorical approach to social psychology.* Cambridge: Cambridge University Press.

Binkley, R. W. (1995). Argumentation, education and reasoning . *Informal Logic, 17*(2), 127-143.

Blanchard, M., Southerland, S., & Granger, E. (2009). No silver bullet for inquiry: Making sense of teacher change following an inquiry-based research experience for teachers. *Science Education, 93*(2), 322-360.

Bochner, A. P., & Rushing, J. H. (2002). Breathing life into work. In A. P. Bochner, & C. Ellis (Eds.), *Ethnographically Speaking: Autoethnography, Literature, and Aesthetics* (pp. 150-164). Walnut Creek, CA: Rowman Altamira.

Bolte, C., Streller, S., Holbrook, J., Rannikmae, M., Hofstein, A., Mamlok-Naaman, R., et al. (2012). Introduction into the PROFILES project and its philosophy. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based science education in Europe: Reflections from the PROFILES project* (pp. 31-41). Berlin: Freie Universität Berlin.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15.

Boulter, C. J., & Gilbert, J. K. (1995). Argument and science education. In P. J. Costello, & S. Mitchell (Eds.), *Competing and Consensual Voices* (pp. 84-98). Clevedon, UK: Multilingual Matters.

Breuer, F., Mruck, K., & Roth, W.-M. (2002). Subjectivity and reflexivity: An introduction. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 3*(3), Art. 9.

Bricker, L. A., & Bell, P. (2008). Conceptualizations of argumentation from science studies and the learning sciences and their implications for the practices of science education. *Science Education, 92*, 473-498.

Britain, S. (2004). *A review of learning design: Concept, specifications and tools.* A report for the JISC E-learning Pedagogy Programme.

Brown, J. J. (2006). *The teacher-self: The role of identity in teaching.* PhD dissertation: University of Massachusetts Lowell.

Burrell, G., & Morgan, G. (1979). *Sociological paradigms and organisational analysis.* London: Heinemann.

Buzard, J. (2003). On auto-ethnographic authority. *The Yale Journal of Criticism, 16*(1), 61-91.

Cavas, B., & Ozdem, Y. (2012). Fen ve teknoloji öğretmenlerinin çevrimiçi öğrenme tasarımı becerilerinin geliştirilmesine yönelik hizmet içi eğitim projesi: LD Skills. [An in-service teacher training project on the development of science and technology teachers' learning design skills] *X. Fen ve Matematik Eğitimi Kongresi*, (p. 17). Nigde.

Cavas, B., Ozdem, Y., Cavas, P., & Kesercioglu, T. (2012). PROFILES: Bilim yoluyla sorgulamaya dayalı öğrenme ve eğitim üzerine mesleki yansıma odaklı bir program. [PROFILES: Professional reflection-oriented focus on inquiry-based learning and education through science] *X. Ulusal Fen bilimleri ve Matematik Eğitimi Kongresi- Bildiri özetleri*, (pp. 672-673). Niğde.

Cetin, P. S., Dogan, N., & Kutluca, A. Y. (2014). The quality of pre-service science teachers' argumentation: Influence of content knowledge. *Journal of Science Teacher Education*, 1-23.

Chang, H. (2007). Autoethnography: Raising cultural consciousness of self and others. In B. Jeffrey, G. Troman, & G. Walford (Ed.), *Studies in Educational Ethnography* (Vol. 12, pp. 207-212). New York: Elsevier.

Chang, H. (2008). *Autoethnography as method.* Walnut Creek, California: Left Coast Press.

Charmaz, K. (2000). Grounded theory: Objectivist and constructivist methods. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of Qualitative Research* (pp. 509-535). Thousand Oaks, Ca.: SAGE.

Christenson, N., Rundgren, S.-N. C., & Zeidler, D. L. (2014). The relationship of discipline background to upper secondary students' argumentation on socioscientific issues. *Research in Science Education*, 1-21.

Churchill, S. D., & Wertz, F. J. (2001). An introduction to phenomenological research in psychology. In K. J. Schneider, J. F. Bugental, & J. F. Pierson (Eds.), *The handbook of humanistic psychology* (pp. 247-262). London: Sage Publications.

Clark, D. B., & Sampson, V. D. (2007). Personally-seeded discussions to scaffold online argumentation. *International Journal of Science Education, 29*(3), 253-277.

Clark, D. B., Stegmann, K., Weinberger, A., Menekse, M., & Erkens, G. (2008). Technology-enhanced learning environments to support students' argumentation. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 217-243). Dordrecht: Springer.

Clarke, D., & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education, 18*, 947–967.

Cobb, P., & Gravemeijer, K. (2008). Experimenting to support and understand learning processes. In A. E. Kelly, R. A. Lesh, & J. Y. Baek (Eds.), *Handbook of Design Research Methods in Education* (pp. 68-95). New york, NY: Routledge.

Collyer, F. (2011). Reflexivity and the sociology of science and technology: The invention of “Eryc” the antibiotic. *The Qualitative Report, 16*(2), 316-340.

Conti, G. J. (2007). Identifying your educational philosophy: Development of the philosophies held by instructors of lifelong-learners (PHIL). *MPAEA Journal of Adult Education, XXXVI*(1), 19-37.

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2 ed.). Thousand Oaks, CA: Sage Publications, Inc.

Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches.* California: SAGE publications.

Creswell, J. W., & Miller, D. L. (2000). Determining Validity in Qualitative Inquiry. *Theory Into Practice, 39*(3), 124-130.

Creswell, J. W., Hanson, W. E., Clark Plano, V. L., & Morales, A. (2007). Qualitative research designs: Selection and implementation. *The Counseling Psychologist, 35*, 236-264.

Daiute, C., & Lightfoot, C. (Eds.). (2004). *Narrative analysis: Studying the development of individuals in society.* Thousand Oaks, CA: Sage Publications, Inc.

Darling-Hammond, L., Hammerness, K. P., Rust, F., & Shulman, L. (2005). The design of teacher education programs. In L. Darling-Hammond, J. Bransford, P. LePage, K. Hammerness, & H. Duffy (Eds.), *Preparing teachers for a changing world: What teachers should learn and be able to do* (pp. 390-441). California: Jossey-Bass.

Davis, E. A., & Krajcik, J. S. (2005). Designing educative curriculum materials to promote teacher learning. *Educational Researcher, 34*(3), 3-14.

Dawson, V. M., & Venville, G. (2010). Teaching strategies for developing students' argumentation skills about socioscientific issuesin high school genetics. *Research in Science Education, 40*, 133-148.

De Geest, E. (2011). Hearing the teachers' voice: Teachers' views of their needs for professional development. *11th International Conference of The Mathematics Education into the 21st Century Project.* Grahamstown, South Africa.

Demir, O. (2012). *Bilim felsefesi [The philosophy of science].* Istanbul: Sentez Yayıncılık.

Denzin, N. K., & Lincoln, Y. S. (2003). *The landscape of qualitative research: Theories and issues.* (N. K. Denzin, & Y. S. Lincoln, Eds.) California, USA: Sage Publications.

Denzin, N. K., & Lincoln, Y. S. (2005). The discipline and practice of qualitative research. In N. K. Denzin, & Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (pp. 1-32). California: SAGE.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*(3), 181-199.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*, 287–312.

Durmuş, S. (2001). Matematik eğitimine oluşturmacı yaklaşımlar [Constructivist approach to mathematics education]. *Kuram ve Uygulamada E¤itim Bilimleri Dergisi, 1*(1), 91–107.

Duschl, R. (1990). *Restructuring science education: The importance of theories and their development.* New York: Teacher's College Press.

Duschl, R. A. (2008). Quality argumentation and epistemic criteria. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 159-175). Dordrecht: Springer.

Duschl, R. A., & Osborne, J. (2002). Supporting and promoting argumentation discourse in science education. *Studies in Science Education, 38*(1), 39-72.

Duschl, R. A., Ellenbogen, K., & Erduran, S. (1999). Promoting argumentation in middle school science classrooms: A project SEPIA evaluation. *Paper presented at the Annual Meeting of the National Association for Research in Science Teaching*, (pp. 1-18). Boston, MA.

Duschl, R. A., Schweingruber, H. A., & Shouse, A. W. (2007). *Taking science to school: Learning and teachig science in grades K-8.* Washington, DC: National Academies Press.

Edelson, D. C. (2002). Design research: What we learn when we engage in design. *The Journal of the Learning Sciences, 11*(1), 105-121.

Ellingson, L. L., & Ellis, C. (2008). Autoethnography as constructionist project. In J. A. Holstein, & J. F. Gubrium (Eds.), *Handbook of constructionist research* (pp. 445-466). New York: Guilford Press.

Ellis, C. (2004). *The ethnographic I: A methodological novel about autoethnography.* Walnut Creek, CA: AltaMira Press.

Ellis, C., Adams, T. E., & Bochner, A. P. (2011). Autoethnography: An overview. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 12*(1), Art. 10.

Erdem, E., & Demirel, Ö. (2002). Program geliştirmede yapılandırmacılık yaklaşımı [Constructivism in curriculum development]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 23*, 81-87.

Erduran, S. (2006). Promoting ideas, evidence and argument in initial science teacher training. *School science review, 87*(321), 45-50.

Erduran, S. (2008). Methodological foundations in the study of argumentation in science classrooms. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 47-69). Dordrecht: Springer.

Erduran, S., & Dagher, Z. (2007). Exemplary teaching of argumentation: A case study of two middle school science teachers. In R. Pinto, & D. Couso (Eds.), *Contributions from Science Education Research* (pp. 403-415). Dordrecht: Springer Academic Publishers.

Erduran, S., & Jiménez-Aleixandre, M. P. (2012). Argumentation in science education research: Perspectives from Europe. In D. Jorde, & J. Dillon (Eds.), *Science education research and practice in Europe: Retrospective and Prospective* (pp. 253-289). Rotterdam, The Netherlands: Sense Publishers.

Erduran, S., & Villamanan, R. (2009). Cool argument: Engineering students' arguments about thermodynamics in the context of Peltier effect in refrigeration. *Educación Química (Special Issue on Argumentation in Science Education), 20*(2), 119-125.

Erduran, S., & Yan, X. (2009). *Minding gaps in argument: Continuing professional development to support the teaching of scientific inquiry.* Resource developed as part of a project "Mind the Gap: Bridging Policy, Research and Practice" funded by the European Union FP7 Programme, Bristol.

Erduran, S., & Yan, X. (2011). Introducing the Bristol resources. In *Science teaching advanced methods: Frameworks for suppporting argumentation in science teaching and learning* (p. 5). As part of the project Science Teaching Advanced Methods funded by the European Union.

Erduran, S., Ardac, D., & Yakmaci-Guzel, B. (2006). Learning to teach argumentation: Case studies of pre-service secondary science teachers. *Euraisa Journal of Mathematics, Science and Technology Education, 2*(2), 1-14.

Erduran, S., Osborne, J., & Simon, S. (2005). The role of argumentation in developing scientific literacy. In K. Boersma, M. Goedhart, O. De Jong, & H. Eijkelhof (Eds.), *Research and the quality of science education* (pp. 381-394). Netherlands: Springer.

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse. *Science Education, 88*, 915-933.

Erduran, S., Yee, W. C., & Ingram, N. (2011). *Assessment and practical inquiry in scientific argumentation (APISA) project: A professional development programme for secondary science teachers.* Bristol.

Ergün, M., & Özsüer, S. (2006). Vygotsky'nin yeniden değerlendirilmesi [A Reevaluation on Vygotsky]. *Afyon Karahisar Üniversitesi Sosyal Bilimler Dergisi, 2*, 269-292.

Eşkin, H. (2008). *Effect of argumentation on students' reasoning in physics.* Unpublished master thesis, Marmara University, Istanbul.

Foley, D. E. (2002). Critical ethnography: The reflexive turn. *International Journal of Qualitative Studies in Education, 15*(4), 469-490.

Fraser, B. J. (2007). Classroom learning environments. In S. K. Abell, & N. G. Lederman (Eds.), *Handbook of Research in Science Education* (pp. 103-124). New Jersey: Lawrence Erlbaum Associates.

Fraser, C., Kennedy, A., Reid, L., & Mckinney, S. (2007). Teachers' continuing professional development: contested concepts, understandings and models. *Journal of In-Service Education, 33*(2), 153-169.

Gadamer, H.-G. (1975). *Truth and Method.* London: Continuum Publishing Group.

Garcia-Mila, M., & Andersen, C. (2008). Cognitive foundations of learning argumentation. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 29-46). Dordrecht: Springer.

Garnham, B. (2008). Data generation. In L. M. Given (Ed.), *The Sage encyclopedia of qualitative research methods.* Seven Oaks, CA: SAGE.

Georghiades, P. (2000). Beyond conceptual change learning in science education: focusing on transfer, durability and metacognition. *Educational Research, 42*(2), 119-139.

Gephart, R. (1999, Summer, Vol.4). *Paradigms and research methods.* Retrieved 11 29, 2013, from Academy of Management, Research Methods Division: http://division.aomonline.org/rm/1999_RMD_Forum_Paradigms_and_Research_ Methods.htm

Gil-Pérez, D., Guisasola, J., Moreno, A., Cachapuz, A., Pessoa De Carvalho, A. M., Torre, J. M., et al. (2002). Defending constructivism in science education. *Science & Education, 11*(6), 557-571.

Grandy, R., & Duschl, R. A. (2007). Reconsidering the character and role of inquiry in school science: Analysis of a conference. *Science & Education, 16*, 141-166.

Gravemeijer, K., & Cobb, P. (2006). Design research from a learning design perspective. In J. van der Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational Design Research* (pp. 17-51). Oxon: Routledge.

Greeno, J. G., Collins, A. M., & Resnick, L. B. (1996). Cognition and learning. In D. C. Berliner, & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 15-46). New York: Macmillan.

Grooms, J., Sampson, V., & Golden, B. (2014). Comparing the effectiveness of verification and inquiry laboratories in supporting undergraduate science students. *International Journal of Science Education*.

Günel, M., & Tanrıverdi, K. (2012). Boylamsal araştırma projesi: Hizmetiçi eğitim ve sınıfiçi uygulamalarının öğretmen pedagojisine, öğrenci akademik başarısına, düşünme becerilerine etkisinin araştırılması. [Longtitudinal research project: The impact of in-service teacher training and classroom applications on teachers' pedagogy, students' academic achievement, and students' thinking skills] *X. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi bildiri özetleri* (p. 643). Niğde, Türkiye: Niğde Üniversitesi.

Günel, M., Kıngır, S., & Geban, Ö. (2012). Analysis of argumentation and questioning patterns in argument-based inquiry classrooms. *Education and Science, 37*(164), 316-330.

Hall, C. B., & Sampson, V. (2009). Inquiry, argumentation, and the phases of the moon: Helping students learn important concepts and practices. *Science Scope, April/ May*, 16-21.

Hand, B., Norton-Meier, L., Staker, J., & Bintz, J. (2009). *Negotiating science: The critical role of argument in student inquiry.* Portsmouth, NH: Heinemann.

Haney, J. J., Lumpe, A. T., Czerniak, C. M., & Egan, V. (2002). From beliefs to actions: The beliefs and actions of teachers implementing change. *Journal of Science Teacher Education, 13*(3), 171-187.

Harland, J., & Kinder, K. (1997). Teachers' continuing professional development: framing a model of outcomes. *Journal of In-Service Education, 23*(1), 71-84.

Hayano, D. M. (1979). Auto-Ethnography: Paradigms, problems, and prospects. *Human Organization, 38*(1), 99-104.

Hein, G. E. (15-22 October 1991). Constructivist learning theory. *CECA (International Committee of Museum Educators) Conference.* Jerusalem Israel.

Hewson, P. W. (2007). Teacher professional development in science. In S. K. Abell, & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 1179-1202). New Jersey: Lawrence Erlabum Associates, Inc.

Hjalmarson, M. A., & Lesh, R. A. (2008). Engineering and design research. In A. E. Kelly, R. A. Lesh, & J. Y. Baek (Eds.), *Handbook of Design Research Methods in Education* (pp. 96-110). New York, NY: Routledge.

Hoban, G. F. (2002). *Teacher learning for educational change: A systems thinking approach .* Buckingham: Open University Press.

Holbrook, J., Cavas, B., Ozdem, Y., & Cavas, P. (2012). Networking among science and technology teachers: Experiences from the PROFILES project in Turkey to reduce heterogeneity in inquiry based science teaching and learning. *Issues of Heterogeneity and Cultural Diversity in Science Education and Science Education Research- Poster session abstracts*, (p. 3). Dortmund University of Technology.

Holloway, I., & Wheeler, S. (2013). *Qualitative Research in Nursing and Healthcare.* Oxford, UK: Wiley-Blackwell.

Irzık, G. (2001). Back to basics: A philosophical critique of constructivism. *Studies in Philosophy and Education, 20*, 157-175.

Jaramillo, J. A. (1996). Vygotsky's sociocultural theory and contributions to the development of constructivist curricula. *Education, 117*(1), 133-140.

Jeanpierre, B., Oberhauser, K., & Freeman, C. (2005). Characteristics of professional development that effect change in secondary science teachers' classroom practices. *Journal of Research in Science Teaching, 42*(6), 668-690.

Jiménez-Aleixandre, M. P. (2008). Designing argumentation learning environments. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 91-115). Dordrecht: Springer.

Jiménez-Aleixandre, M. P., & Erduran, S. (2008). Argumentation in science education: An overview. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 3-27). Dordrecht: Springer.

Jiménez-Aleixandre, M. P., & Pereiro-Munoz, C. (2002). Knowledge producers or knowledge consumers? Argumentation and decision making about environmental management. *International Journal of Science Education, 24*(11), 1171–1190.

Jiménez-Aleixandre, M. P., & Pereiro-Munoz, C. (2005). Argument construction and change while working on a real environment problem. In K. Boersma, M. Goedhart, O. De Jong, & H. Eijkelhof (Eds.), *Research and the quality of science education* (pp. 419-431). Netherlands: Springer.

Jiménez-Aleixandre, M. P., Gallástegui, J. R., Eirexas, F., Puig, B., Fernández, L., López, R., et al. (2011). Introducing the Santiago resources. In *Science teaching advanced methods: Frameworks for supporting argumentation in science teaching and learning* (p. 4). As part of the project Science Teaching Advanced Methods funded by the European Union.

Jiménez-Aleixandre, M. P., Rodriguez, A. B., & Duschl, R. A. (2000). "Doing the lesson" or "Doing science": Argument in high school genetics. *Science Education, 84*, 757-792.

Kassarjian, H. H. (1977). Content analysis in consumer research. *The journal of Consumer Research, 4*(1), 8-18.

Kelly, A. E., Baek, J. Y., Lesh, R. A., & Bannan-Ritland, B. (2008). Enabling innovations in education and systematizing their impact. In A. E. Kelly, R. A. Lesh, & J. Y. Baek (Eds.), *Handbook of Design Research Methods in Education* (pp. 3-18). New York, NY: Routledge.

Kelly, A. E., Lesh, R. A., & Baek, J. Y. (Eds.). (2008). *Handbook of design research methods in education.* New York, NY: Routledge.

Kelly, G. J., & Bazerman, C. (2003). How students argue scientific claims: A rhetorical-semantic analysis. *Applied Linguistics, 24*(1), 28-55.

Kelly, G. J., & Chen, C. (1999). The sound of music: Constructing science as sociocultural practices through oral and written discourse. *Journal of research in science teaching, 36*(8), 883-915.

Kelly, G. J., Druker, S., & Chen, C. (1998). Students' reasoning about electricity: Combining performance assessments with argumentation analysis. *International Journal of Science Education, 20*(7), 849-871.

Kelly, G. J., Regev, J., & Prothero, W. (2008). Analysis of lines of reasoning in written argumentation. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 137-157). Dordrecth: Springer.

Kelly, P. (2006). What is teacher learning? A socio-cultural perspective. *Oxford Review of Education, 32*(4), 505-519.

Kennedy, A. (2005). Models of continuing professional development: A framework for analysis. *Journal of In-service Education, 31*(2), 235-250.

Khishfe, R. (2014). Explicit nature of science and argumentation instruction in the context of socioscientific issues: An effect on student learning and transfer. *International Journal of Science Education, 36*(6), 974-1016.

Kilpatrick, J. (July, 1987). What constructivism might be in mathematics education. *Proceedings of the eleventh conference of the international group for the psychology of mathematics education. 1*, pp. 3-27. Montreal: Universidad de Montreal.

Kim, H., & Song, J. (2006). The features of peer argumentation in middle school students' scientific inquiry. *Research in Science Education, 36*, 211-233.

Kingir, S., Geban, O., & Gunel, M. (2012). How does the science writing heuristic approach affect students' performances of different academic achievement levels? A case for high school chemistry. *Chemistry Education Research and Practice, 13*, 428–436.

Koç, G., & Demirel, M. (2004). Davranışçılıktan yapılandırmacılığa: Eğitimde yeni bir paradigma [From behaviorism to constructivism: A new paradigm in education]. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 27*, 174-180.

Kolsto, S. D. (2001). Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues. *Science Education, 85*, 291-310.

Kolsto, S. D. (2006). Patterns in students' argumentation confronted with a risk-focused socio-scientific issue. *International Journal of Science Education, 28*(14), 1689-1716.

Kolsto, S. D., & Ratcliffe, M. (2008). Social aspects of argumentation. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 116-136). Dordrecht: Springer.

Koper, R., & Olivier, B. (2004). Representing the learning design of units of learning. *Journal of Educational Technology & Society, 7*(3), 97-111.

Kuhn, D. (1991). *The Skills of Argument.* New York: Cambridge University Press.

Kuhn, D. (1993). Science as argument: Implications for teaching and learning scientific thinking. *Science Education, 77*(3), 319-337.

Kuhn, D., & Udell, W. (2003). The development of argument skills. *Child Development, 74*(5), 1245-1260.

Kuhn, L., & Reiser, B. J. (2006). Structuring activities to foster argumentative discourse. *American Educational Research Association.* San Francisco, CA.

Kuhn, T. S. (1970). *The structure of scientific revolutions* (2, enlarged ed.). Chicago, USA: The University of Chicago Press.

Lakatos, I. (1978). *The methodology of scientific research programs.* Cambridge: Cambridge University Press.

Larkin, M., Watts, S., & Clifton, E. (2006). Giving voice and making sense in interpretative phenomenological analysis. *Qualitative Research in Psychology, 3*(2), 102-120.

Larrain, A., Freire, P., & Howe, C. (2014). Science teaching and argumentation: One-sided versus dialectical argumentation in Chilean middle-school science lessons. *International Journal of Science Education, 36*(6), 1017-1036.

Lauckner, H., Paterson, M., & Krupa, T. (2012). Using constructivist case study methodology to understand community development processes: Proposed methodological questions to guide the research process. *The Qualitative Report, 17*, 1-22.

Lawson, A. E. (2003). The nature and development of hypothetico-predictive argumentation with implications for science teaching. *International Journal of Science Education, 25*(11), 1387-1408.

Lawson, A. E. (2010). Basic inferences of scientific reasoning, argumentation, and discovery. (J. Osborne, & M. P. Jiménez-Aleixandre, Eds.) *Science Education, 94*, 336 – 364.

Leach, J., & Scott, P. (2002). Designing and evaluating science teaching sequences: An approach drawing upon the concept of learning demand and a social constructivist perspective on learning. *Studies in Science Education, 38*, 115-142.

Lee, M. H., Wu, Y. T., & Tsai, C. C. (2009). Research trends in science education from 2003 to 2007: A content analysis. *International Journal of Science Education, 31*(15), 1999–2020.

Lester, S. (1999). *An introduction to phenomenological research .* Retrieved Jan 29, 2014, from Stan Lester Developments, Taunton, UK: http://www.sld.demon.co.uk/resmethy.pdf

Loucks-Horsley, S., Stiles, K. E., Mundry, S., Love, N., & Hewson, P. W. (2010). *Designing professional development for teachers of science and mathematics.* Thousand Oaks, California: Corwin Press.

Loughran, J. (2007). Science teacher as learner. In S. K. Abell, & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 1043-1066). New Jersey: Lawrence Erlbaum Associates, Inc.

Loughran, J. (2014). Professionally developing as a teacher educator. *Journal of Teacher Education*, 1-13.

Mackenzie, N., & Knipe, S. (2006). Research dilemmas: Paradigms, methods and methodology. *Issues in Educational Research, 16*.

Majgaard, G., Misfeldt, M., & Nielsen, J. (2011). How design-based research and action research contribute to the development of a new design for learning. *Designs for Learning, 4*(2), 8-27.

Manning, K. (2000). *Rituals, ceremonies, and cultural meaning in higher education.* Westport, CT: Greenwood Publishing Group.

Mansour, N., El-Deghaidy, H., Alshamrani, S., & Aldahmash, A. (2014). Rethinking the theory and practice of continuing professional development: Science teachers' perspectives. *Research in Science Education, online first*.

Maréchal, G. (2010). Encyclopedia of case study research. In A. J. Mills, G. Durepos, & E. Wiebe (Eds.). London: Sage Publications.

Mason, L., & Santi, M. (1994). *Argumentation structure and metacognition in constructing shared knowledge at school.* New Orleans, LA: ERIC.

Matthews, B., & Jessel, J. (1998). Reflective and reflexive practice in initial teacher education: A critical case study. *Teaching in Higher Education, 3*(2), 231-243.

Matthews, M. R. (1999). Social constructivism and mathematics education: Some comments. *Philosophy of Education*, 330-341.

Matthews, M. R. (2002). Constructivism and science education: A further appraisal. *Journal of Science Education and Technology, 11*(2), 121-134.

Mayring, P. (2000). Qualitative content analysis. *Forum: Qualitative Social Research, 1*(2).

McDonald, S. P., & Kelly, G. J. (2012). Beyond argumentation: Sense-making discourse in the science classroom. In M. S. Khine (Ed.), *Perspectives on Scientific Argumentation: Theory, Pactice and Research* (pp. 265-281). New York: Springer.

McKenney, S., & Reeves, T. C. (2012). *Conducting educational design research.* London: Routledge.

McNeill, K. L. (2009). Teachers' use of curriculum to support students in writing scientific arguments to explain phenomena. *Science Education, 93*, 233-268.

McNeill, K. L., & Knight, A. M. (2013). Teachers' pedagogical content knowledge of scientific argumentation: The impact of professional development on K-12 teachers. *Science Education, 97*, 936-972.

McNeill, K. L., & Krajcik, J. (2008). Scientific explanations: Characterizing and evaluating the effects of teachers' instructional practices on student learning. *Journal of Research in Science Teaching, 45*(1), 53-78.

McNeill, K. L., & Pimentel, D. S. (2010). Scientific discourse in three urban classrooms: The role of the teacherin engaging high school students in argumentation. *Science Education, 94*, 203-229.

McNeill, K. L., Gonzalez-Howard, M., Katsh-Singer, R., & Loper, S. (2014). Measuring pedagogical content knowledge of argumentation through the development of a teacher argumentation assessment. *Paper presented at the annual meeting of the National Association for Research in Science Teaching.* Pittsburgh, PA.

Merriam, S. B. (2002). Introduction to qualitative research. In S. B. Merriam (Ed.), *Qualitative research in practice: Examples for discussion and analysis* (pp. 1–33). San Francisco: Jossey-Bass.

Ministry of National Education in Turkey (MNE) (2006). *İlköğretim fen ve teknoloji dersi (6, 7 ve 8. sınıflar) öğretim programı [Elementary Science and Technology Curriculum (6th, 7th and 8th grades)].* Ankara: Talim ve Terbiye Kurulu Başkanlığı.

Ministry of National Education in Turkey (MNE) (2013). *İlköğretim kurumları (ilkokullar ve ortaaokullar) fen bilimleri dersi (3, 4, 5, 6, 7 ve 8. sınıflar) öğretim programı [Elementary (primary and middle school) Science Curriculum (3rd, 4th, 5th, 6th, 7th and 8th grades)].* Ankara: Talim ve Terbiye Kurulu Başkanlığı.

Morine-Dershimer, G., & Kent, T. (1999). The complex nature and sources of teachers' pedagogical knowledge. In J. Gess-Newsome, & N. G. Lederman (Eds.), *PCK and Science Education* (pp. 21-50). The Netherlands: Kluwer Academic Publishers.

Mork, S. M. (2005). Argumentation in science lessons: Focusing on the teacher's role. *Nordic Studies in Science Education, 1*(1), 17-30.

Mortimer, E. F., Scott, P., & El-Hani, C. N. (2012). The heterogeneity of discourse in science classrooms: The conceptual profile approach. In B. J. Fraser, K. G. Tobin, & C. J. McRobbie (Eds.), *Second International Handbook of Science Education* (Vol. 1, pp. 231-246). Springer.

Myers, M. D. (2013). *Qualitative research in business and management.* London: SAGE Publications.

Nagata, A. L. (2004). Promoting self-reflexivity in intercultural education. *Journal of Intercultural Communication, 8*, 139-167.

Neumann, K., Kauertz, A., & Fischer, H. E. (2012). Quality of instruction. In *Second international handbook of science education* (Vol. 1, pp. 247-258). Springer.

Newton, P., Driver, R., & Osborne, J. (1999). The place of argumentation in the pedagogy of school science. *International Journal of Science Education, 21*(5), 553-576.

Nowacek, S. L. (2008). *A critical examination of practices and perceptions of current performance evaluation models for theatre arts teachers in Virginia.* PhD dissertation: The College of William and Mary, Virginia.

National Research Council (NRC) (2012). *A framework for k-12 science education: Practices, crosscutting concepts and core ideas.* Washington, DC: The National Academies Press.

Osborne, J. (2005). The role of argument in science education. In K. Boersma, M. Goedhart, O. De Jong, & H. Eijkelhof (Eds.), *Research and the quality of science education* (pp. 367-380). Netherlands: Springer.

Osborne, J. (2010). Arguing to learn in science: The role of collaborative, critical discourse. *Science, 328*(5977), 463-466.

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching, 41*(10), 994–1020.

Osborne, J., Simon, S., Christodoulou, A., Howell-Richardson, C., & Richardson, K. (2011). Developing the teaching of arumentation and its effect on student outcomes. *Science learning and citizenship.* Lyon, France: European Science Education Research Association.

Oxford Dictionaries. (2014). Retrieved 01 29, 2014, from

http://www.oxforddictionaries.com/definition/english/phenomenology?q=phenomenology

Ozdem, Y. (2009). *The nature of pre-service science teachers' argumentation in inquiry-oriented laboratory context.* Unpublished Master Thesis. Middle East Technical University: Ankara.

Ozdem, Y., & Cavas, B. (2012). PROFILES continuous professional development workshops in Turkey. In C. Bolte, J. Holbrook, & F. Rauch (Eds.), *Inquiry-based science education in Europe: Reflections from the PROFILES project* (pp. 163-165). Berlin: Freie Universität Berlin.

Ozdem, Y., Erduran, S., & Park, J.-Y. (2011). The development of an argumentation theory in science education. *European Science Education Research Association (ESERA).* Lyon.

Ozdem, Y., Ertepinar, H., Cakiroglu, J., & Erduran, S. (2013). The nature of pre-service science teachers' argumentationin inquiry-oriented laboratory context. *International Journal of Science Education, 35*(15), 2559–2586.

Ozdem, Y., Ertepinar, H., Cakiroglu, J., & Topcu, M. S. (2009). The nature of pre-service science teachers' argumentation in laboratory work. *Theory and evidence in European educational research.* Vienna: European Conference on Educational Research.

Ozmon, H. A. (2012). *Philosophical foundations of education* (9th ed.). Upper Saddle River, New Jersey: Pearson Education, Inc.

Ozmon, H. A., & Craver, S. M. (1981). *Philosophical foundations of education* (2 ed.). Columbus, OH: Merrill Publishing Co.

Packer, M. (2011). *The science of qualitative research.* NY: Cambridge University Press.

Palincsar, A. S. (1998). Social constructivist perspectives on teaching and learning. *Annual Review of Psychology, 49*(1), 345-375.

Patronis, T., Potari, D., & Spiliotopoulou, V. (1999). Students' argumentation in decision-making on a socio-scientific issue: Implications for teaching. *International Journal of Science Education, 21*(7), 745-754.

Peressini, D., Borko, H., Romagnano, L., Knuth, E., & Willis, C. (2004). A conceptual framework for learning to teach secondary mathematics: A situative perspective. *Educational Studies in Mathematics, 56*, 67-96.

Pimentel, D. S., & McNeill, K. L. (2013). Conducting talk in secondary science classrooms: Investigating instructional moves and teachers' beliefs. *Science Education, 97*, 367-394.

Popkewitz, T. S. (1984). *Paradigm and ideology in educational research : the social functions of the intellectual.* New York: Falmer Press.

Promyod, N. (2013). *Investigating the shifts in Thai teachers' views of learning and pedagogical practices while adopting an argument-based inquiry approach.* PhD dissertation: University of Iowa.

Racher, F. E., & Robinson, S. (2002). Are phenomenology and postpositivism strange bedfellows? *Western Journal of Nursing Research, 25*(5), 464-481.

Ratner, C. (2002). Subjectivity and Objectivity in Qualitative Methodology. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 3*(3), Art. 16.

Rauch, F., Holbrook, J., & Bolte, C. (Eds.). (2011, August). *PROFILES (Professional Reflection Oriented Focus on Inquiry-based Learning and Education through science).* Retrieved June 05, 2014, from Dissemination: http://www.profiles-project.eu/res/Newsletters/PROFILES-Newsletter-1_formatiert.pdf?1383911997

Reeves, T. C., & Hedberg, J. G. (2003). *Interactive learning systems evaluation.* Englewood Cliffs, NJ: Educational Technology Publications.

Reeves, T. C., McKenney, S., & Herrington, J. (2011). Publishing and perishing: The critical importance of educational design research. *Australasian Journal of Educational Technology, 27*(1), 55-65.

Reid, K., Flowers, P., & Larkin, M. (2005). Exploring lived experience. *The Psychologist, 18*(1), 20-23.

Riessman, C. K. (2004). Narrative analysis. In M. S. Lewis-Beck, A. Bryman, & T. F. Liao (Eds.), *Encyclopedia of social science research methods.* Thousand Oaks, CA: SAGE Publications, Inc.

Rodriguez, N., & Ryave, A. (2002). *Systematic self-observation: A method for researching the hidden and elusive features of everyday social life.* Thousand Oaks, California: Sage.

Rovai, A. P. (2004). A constructivist approach to online college learning. *Internet and Higher Education, 7*, 79-93.

Ryan, G. W., & Bernard, H. R. (2000). Data management and analysis methods. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of Qualitative Research* (pp. 769-802). Thousand Oaks: Sage.

Ryan, T. (2005). When you reflect are you also being reflexive. *The Ontario Action Researcher, 8*(1).

Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching, 41*(5), 513-536.

Sadler, T. D. (2006). Promoting discourse and argumentation in science teacher education. *Journal of Science Teacher Education, 17*, 323–346.

Sampson, V. (2007). *The effects of collaboration on argumentation outcomes.* PhD dissertation: Arizona State University.

Sampson, V. (2009). Learning from and about scientific argumentation in the classroom. *Invited seminar, 1st Turkish Doctoral Symposium in Science Education.* Ahi Evran University, Kırsehir.

Sampson, V., & Blanchard, M. R. (2012). Science teachers and scientific argumentation: Trends in views and practice. *Journal of Research in Science Teaching, 49*(9), 1122-1148.

Sampson, V., & Clark, D. (2008). Assessment of the ways students generate arguments in science education: Current perspectives and recommendations for future directions. *Science Education, 92*, 447-472.

Sampson, V., & Clark, D. (2009). The impact of collaboration on the outcomes of scientific argumentation. *Science Education, 93*, 448-484.

Sampson, V., Enderle, P., Grooms, J., & Witte, S. (2013). Writing to learn by learning to write during the school science laboratory: Helpig middle and high school students develop argumentative writing skills as they learn core ideas. *Science Education, 97*, 643-670.

Sampson, V., Grooms, J., & Walker, J. (2009). Argument-driven inquiry: A way to promote learning during laboratory activities. *The Science Teacher, November*, 42-47.

Sampson, V., Grooms, J., & Walker, J. P. (2011). Argument-driven inquiry as a way to help students learn how to participate in scientific argumentation and craft written arguments: An exploratory study. *Science Education, 95*, 217-257.

Sandoval, W. A., & Millwood, K. A. (2005). The quality of students' use of evidence in written scientific explanations. *Cognition and Instruction, 23*(1), 23-55.

Sandoval, W. A., & Millwood, K. A. (2008). What can argumentation tell us about epistemology? In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 71-90). Dordrecht: Springer.

Sandoval, W. A., & Reiser, B. J. (2004). Explanation-driven inquiry: Integrating conceptual and epistemic scaffolds for scientific inquiry. *Science Education, 88*, 345-372.

Savery, J. R., & Duffy, T. M. (2001). *Problem based learning: An instructional model and its constructivist framework.* Bloomington, IN: The Center for Research on Learning and Technology, Indiana University.

Schaller, J. S., & Tobin, K. (1998). Quality criteria for the genres of interpretive research. In J. A. Malone, B. Atweh, & J. Northfield (Eds.), *Research and Supervision in Mathematics and Science Education* (pp. 39-60). Manwah, NJ: Routledge.

Schen, M. (2013). A comparison of biology majors' written arguments across the curriculum. *Journal of Biological Education*.

Schmidt, L. K. (2006). *Understanding Hermeneutics.* Durham, GBR: Acumen.

Schussler, D. L., Stooksberry, L. M., & Bercaw, L. A. (2010). Understanding teacher candidate dispositions: Reflecting to build self-awareness. *Journal of Teacher Education, 61*(4), 350–363.

Schwandt, T. (1994). Constructivist, interpretivist approaches to human inquiry. In N. Denzin, & Y. Lincoln (Eds.), *Handbook of qualitative research* (pp. 118-137). Thousand Oaks, CA: Sage.

Schwartz, D. L., Chang, J., & Martin, L. (2008). Instrumentation and innovation in design experiments. In A. E. Kelly, R. A. Lesh, & J. Y. Baek (Eds.), *Handbook of Design Research Methods in Education* (pp. 47-67). New York, NY: Routledge.

Schwartz-Shea, P. (2006). Judging quality. In D. Yanow, & P. Schwartz-Shea (Eds.), *Interpretation and Method: Empirical Research Methods and the Interpretive Turn* (pp. 89-114). New York: M.E. Sharpe.

Schwartz-Shea, P., & Yanow, D. (2012). *Interpretive research design: Concepts and processes.* New York: Routledge.

Science Teacher Education Advanced Methods (S-TEAM). (2010). *Report on argumentation and teacher education in Europe.* Trondheim: S-TEAM /NTNU.

Shulman, L. S., & Shulman, J. H. (2004). How and what teachers learn: A shifting perspective. *Journal of Curriculum Studies, 36*(2), 257-271.

Siegel, H. (1995). Why should educators care about argumentation? *Informal Logic, 17*(2), 159-176.

Simon, S., & Campbell, S. (2012). Teacher learning and professional development in science education. In B. J. Fraser, K. G. Tobin, & C. J. McRobbie (Eds.), *Second international handbook of science education* (pp. 307-321). Dordrecht: Springer.

Simon, S., Erduran, S., & Osborne, J. (2006). Learning to teach argumentation: Research and development in the science classroom. *International Journal of Science Education, 28*(2), 235-260.

Simon, S., & Johnson, S. (2008). Professional learning portfolios for argumentation in school science. *International Journal of Science Education, 30*(5), 669-688.

Simon, S., Richardson, K., Howell-Richardson, C., Christodolou, A., & Osborne, J. (2010). Professional development in the use of discussion and argument in secondary school science departments. *International Seminar, Professional Reflections, National Science.* York.

Simonneaux, L. (2008). Argumentation in socio-scientific contexts. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 179-199). Dordrecht: Springer.

Smith, D. W. (2013, Dec 16). *Phenomenology*. (E. N. Zalta, Editor) Retrieved 01 29, 2014, from Stanford Encyclopedia of Philosophy:

http://plato.stanford.edu/entries/phenomenology/#1

Smith, J. A. (2004). Reflecting on the development of interpretative phenomenological analysis and its contribution to qualitative research in psychology. *Qualitative Research in Psychology, 1*(1), 39-54.

Smith, J. A., & Osborn, M. (2008). Interpretive phenomenological analysis. In J. A. Smith (Ed.), *Qualitative Psychology: A Practical Guide to Research Methods* (pp. 53-80). London: Sage.

Smyth, J., & Shacklock, G. (2002). Behind the cleansing of socially critical research accounts. In G. Shacklock, & J. Smyth (Eds.), *Being Reflexive in Critical and Social Educational Research* (pp. 1-12). Routledge.

St. Louis, K., & Calabrese Barton, A. (2002). Tales from the science education crypt: A critical reflection of positionality, subjectivity, and reflexivity in research. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 3*(3), Art. 19.

Stake, R. (1995). *The art of case study research.* Thousand Oaks, CA: Sage.

Steiner, D. M. (2014). Learning, constructivist theories of. *Value inquiry book series: Global studies encyclopedic dictionary, 276*, 319-320.

Storey, L. (2007). Doing interpretative phenomenological analysis. In E. Lyons, & A. Coyle (Eds.), *Analysing Qualitative Data in Psychology* (pp. 51-64). London: Sage Publications Ltd.

Struthers, J. (2012). *Analytic autoethnography: a tool to inform the lecturer's use of self when teaching mental health nursing?* Lancaster University, UK: Unpublished PhD dissertation.

Sullivan, G. B. (2002). Reflexivity and subjectivity in qualitative research: The utility of a Wittgensteinian framework. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 3*(3), Art. 20.

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching, 37*(9), 963-980.

Şimşek, N. (2004). Yapılandırmacı öğrenme ve öğretime eleştirel bir yaklaşım [A critical approach to constructive learning and instruction]. *Eğitim Bilimleri ve Uygulama, 3*(5), 115-139.

Tanriverdi, K., Demirbag, M., & Gunel, M. (2011). Discussion session: Critical elements of implementing argumentation based science inquiry and multi modal representations; Focusing on pedagogy. *International Symposium on Science Education (ISSE): Strategies to engage students for learning.* Helsinki, Finland.

Taylor, P. C., Taylor, E. L., & Luitel, B. C. (2012). Multi-paradigmatic transformative research as/for teacher education: An integral perspective. In B. J. Fraser, K. G. Tobin, & C. J. McRobbie (Eds.), *Second International Handbook of Science Education* (pp. 373-388). Dordrecht: Springer.

The LD-Skills vision: Objectives. (2013). Retrieved 06 02, 2014, from LD-Skills:

http://www.ea.gr/ep/ld-skills/

Thomas, P. Y. (2010). *Towards developing a web-based blended learning environment at the University of Botswana.* PhD dissertation: University of South Africa.

Thompson, P. W. (2000). Radical constructivism: Reflections and directions. In L. P. Steffe, & P. W. Thompson (Eds.), *Radical constructivism in action: Building on the pioneering work of Ernst von Glasersfeld* (pp. 412-448). London: Falmer Press.

Tiberghien, A. (2008). Preface. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. i-iii). Dordrecht, The Netherlands: Springer.

Tiberghien, A., Vince, J., & Gaidioz, P. (2009). Design-based research: Case of a teaching sequence on mechanics. *International Journal of Science Education, 31*(17), 2275-2314.

Tiberghien, A., Vince, J., Coince, D., & Malkoun, L. (2011). Introducing the Lyon resources. In *Science teaching advanced methods: Framewroks for supporting argumentation in science teaching and learning* (p. 3). As part of the project Science Teaching Advanced Methods funded by the European Union.

Tobin, K. G. (2006). Qualitative research in classrooms: Pushing the boundaries of theory and methodology. In K. Tobin, & J. L. Kincheloe (Eds.), *Doing Educational Research- A Handbook* (pp. 15-58). The Netherlands: Sense Publishers.

Tobin, K., & Tippins, D. (1993). Constructivism as a referent for teaching and learning. In K. Tobin (Ed.), *The practice of constructivism in science education* (pp. 3-22). Hillsdale, NJ.: Lawrence-Erlbaum.

Topçu, M. S., Yılmaz-Tüzün, Ö., & Sadler, T. D. (2011). Turkish pre-service science teachers' informal reasoning regarding socioscientific issues and the factors influencing their informal reasoning. *Journal of Science Teacher Education, 22*, 313-332.

Toulmin, S. E. (1958). *The uses of argument.* Cambridge: Cambridge University Press.

Tümay, H. (2008). *Argumentation focused chemistry teaching.* Ankara: Unpublished PhD dissertation, Gazi University.

Tümay, H., & Köseoğlu, F. (2010). Bilimde argümantasyona odaklanan etkinliklerle kimya öğretmen adaylarının bilimin doğası hakkındaki anlayışlarını geliştirme. *Gazi Eğitim Fakültesi Dergisi, 30*(3), 859-876.

Uluçınar-Sağır, Ş. (2008). *Investigation of effectiveness of argumentation theory based teaching in science courses.* Unpublished Doctoral Dissertation, Gazi University, Ankara.

Ünder, H. (2010). Manifestations of epistemological theses of constructivism in the science and technology programs of Turkish elementary education. *Eğitim ve Bilim, 35*(158), 199-214.

van Eemeren, F. H., & Grootendorst, R. (1988). Rationale for a pragma-dialectical perspective. *Argumentation, 2*(2), 271-291.

van Eemeren, F. H., Grootendorst, R., Henkemans, F. S., Blair, J. A., Johnson, R. H., Krabbe, E. C., et al. (1996). *Fundamentals of arguemntation theory: A handbook of historical backgrounds and contemporary developments.* Mahwah, NJ: Lawrence Erlbaum Associates.

van Manen, M. (1990). *Researching lived experience: Human science for an action sensitive pedagogy.* Ontario: SUNY Press.

von Glasersfeld, E. (1984). An introduction to radical constructivism [English translation of: Glasersfeld, E. (1981) Einführung in den Radikalen Konstruktivismus]. In *The invented reality [Die Erfundene Wirklichkeit]* (pp. 17–40). New York: Norton.

von Glasersfeld, E. (1995). *Radical constructivism: A way of knowing and learning.* London: The Falmer Press.

von Glasersfeld, E. (2000). Problems of constructivism. In L. P. Steffe, & P. W. Thompson (Eds.), *Radical constructivism in action. Building on the pioneering work of Ernst von Glasersfeld* (pp. 1-9). London: Routledge/Falmer.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Harvard University Press.

Waghid, Y. (2002). Knowledge production and higher education transformation in South Africa: Towards reflexivity in university teaching, research and community service. *Higher Education, 43*, 457–488.

Walker, J. P., & Sampson, V. (2013). Learning to argue and arguing to learn: Argument-driven inquiry as a way to help undergraduate chemistry students learn how to construct arguments and engage in argumentation during a laboratory course. *Journal of Research in Science Teaching, 50*(5), 561-596.

Walker, J. P., Sampson, V., Grooms, J., Anderson, B., & Zimmerman, C. O. (2012). Argument-driven inquiry in undergradute chemistry labs: The impact on students' conceptual understanding, argument skills, and attitudes toward science. *Journal of College Science Teaching, 41*(4), 74-81.

Walker, M., & Unterhalter, E. (2004). Knowledge, narrative and national reconciliation: storied reflections on the South African truth and Reconciliation Commission. *Discourse: Studies in the Cultural Politics of Education, 25*, 279-297.

Wallace, J. (2003). Learning about teacher learning: Reflections of a science educator. In J. Wallace, & J. Loughran (Eds.), *Leadership and professional development in science education: New possibilities for enhancing teacher learning* (pp. 1-16). London: Routledge Falmer.

Wallace, J., & Loughran, J. (2012). Science teacher learning. In B. J. Fraser, K. G. Tobin, & C. J. McRobbie (Eds.), *Second international handbook of science education* (pp. 295-306). Dordrecht: Springer.

Walton, D. (1999). The new dialectic: A method of evaluating an argument used for some purpose in a given case. *ProtoSociology, 13*, 70-91.

Walton, D. N. (2001). Abductive, presumptive and plausible arguments. *Informal Logic, 21*(2), 141-169.

Wilson, B. G. (1993). Constructivism and educational design: Some personal reflections. *Proceedings of selected research an development presentations at the convention of the Assocation for Educational Communications and Technology* (pp. 1131-1149). New Orleans, Louisiana: Reseach and Theory Division.

Wilson, S. M. (1990). A conflict of interests: The case of Mark Black. *Educational Evaluation and Policy Analysis, 12*, 293-310.

Yan, X., & Erduran, S. (2008). Arguing online: Case studies of pre-service science teachers' perceptions of online tools in supporting the learning of arguments. *Turkish Science Education, 5*(3), 2-31.

Yang, L., & Wilson, K. (2006). Second language classroom reading: Asocial constructivist approach. *Reading Matrix: An International Online Journal, 6*(3).

Yardley, L. (2008). Demonstrating validity in qualitative psychology. In J. A. Smith (Ed.), *Qualitative Psychology: A Practical Guide to Research Methods* (pp. 235-251). London: Sage Publications, Inc.

Yeşiloğlu, S. N. (2007). *Gazlar konusunun lise öğrencilerine bilimsel tartışma (argümantasyon) odaklı yöntemle öğretimi.* Unpublished master's thesis, Gazi University, Ankara, Turkey.

Yıldırım, K. (2010). Nitel araştırmalarda niteliği artırma [Raising the quality in qualitative research]. *İlköğretim Online, 9*(1), 79-92.

Yıldırır, H. E., & Nakiboğlu, C. (2013). The views of chemistry teachers and pre-service teachers on the preparation and implementation of argumentation-based chemistry lessons. *Journal of Turkish Science Education, 10*(3), 185-210.

Yin, R. K. (2009). *Case study research: Design and methods (4th ed.).* Thousand Oaks, CA: Sage.

Young, R. A., & Collin, A. (2004). Introduction: Constructivism and social constructionism in the career field. *Journal of Vocational Behavior, 64*, 373–388.

Yurdakul, B. (2004). Eğitimde davranışçılıktan yapılandırmacılığa geçiş için bilgi, gerçeklik ve öğrenme olgularının yeniden anlamlandırılması [The reconceptualization of the knowledge, reality and learning constructs for transition from behaviorism to constructivism in educ]. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 4*(8), 109-120.

Zawojewski, J., Chamberlin, M., Hjalmarson, M. A., & Lewis, C. (2008). Developing design studies in mathematics education professional development. In A. E. Kelly, R. A. Lesh, & J. Y. Baek (Eds.), *Handbook of Design Research Methods in Education* (pp. 219-245). New York, NY: Routledge.

Zeidler, D. L., & Sadler, T. D. (2008). The role of moral reasoning in argumentation: Conscience, character, and care. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 201-216). Dordrecht: Springer.

Zembal-Saul, C. (2009). Learning to teach elementary school science as argument. *Science Education, 93*, 687-719.

Zembal-Saul, C., Munford, D., Crawford, B., Friedrichsen, P., & Land, S. (2002). Scaffolding preservice science teachers' evidence-based arguments during an investigation of natural selection. *Research in Science Education, 32*, 437-463.

Zhou, G. (2010). Conceptual change in science: A process of argumentation. *Eurasia Journal of Mathematics, Science & Technology Education, 6*(6), 101-110.

Zohar, A. (2006). The nature and development of teachers' metastrategic knowledge in the context of teaching higher order thinking. *Journal of the Learning Sciences, 15*(3), 331-377.

Zohar, A. (2008). Science teacher education and professional development in argumentation. In S. Erduran, & M. P. Jiménez-Aleixandre (Eds.), *Argumentation in science education: Perspectives from classroom-based research* (pp. 245-268). Dordrecht: Springer.

Zohar, A. (2012). *Explicit teaching of metastrategic knowledge: Definitions, students' learning, and teachers' professional development.* (A. Zohar, & Y. J. Dori, Eds.) Dordrecht: Springer.

Zohar, A., & David, A. B. (2008). Explicit teaching of meta-strategic knowledge in authentic classroom situations. *Metacognition and Learning, 3*(1), 59-82.

Zohar, A., & Nemet, F. (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching, 39*(1), 35-62.

Zohar, A., & Peled, B. (2008). The effects of explicit teaching of metastrategic knowledge on low- and high-achieving students. *Learning and Instruction, 18*, 337-353.

APPENDICES

A. PRE-INTERVIEW QUESTIONS

Thank you for taking time to have an interview with me today. This interview will probably take about 20-30 minutes to complete. As I mentioned to you before, we are doing these interviews with the graduates of science education and enrolled in the course ‘Argumentation in Science Teaching and Learning’. The information from these interviews will be pulled together and used to inform my PhD study which is about argumentation, and to improve the professional development and support provided by the course. This interview will be used for this purpose only and will be confidential, that is I will not identify you by name in the report or in any conversations with other people.

1. Would you mind to share with me your background related to your career as a science teacher?

2. Do you have any teaching experience?

Argumentation related questions

1. How do you think a classroom discourse (interaction between students-students and student-teacher related to a science concept/ issue) could be productive in terms of science learning? What are the pre-requisites and what are the necessities of good discourse environment?

2. How do you initiate and flourish discourse in your classroom? What are the strategies you use?

3. How can you decide that a student’s contribution to a discourse is effective/productive?

4. Which statement provides the strongest support for the claim that “matter is made up of particles” (the particle theory of matter)?

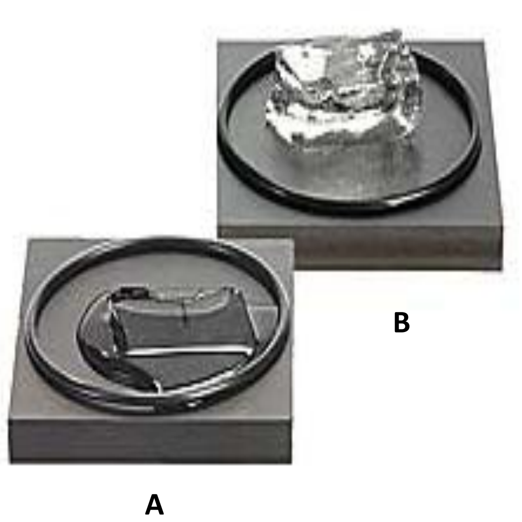
a. The air inside a syringe can be compressed
b. All crystals composing a solid matter have similar shape

c. Water inside a small pond disappears in a while

d. Paper can be divided into very small pieces

5. The case is that:

There are two blocks: Block A and Block B. They are not identical. The blocks are at room temperature. The teacher places two identical ice cubes on these blocks. Students observe in a while that the ice cube on Block A melts faster than the ice cube on Block B.



The question asked to the students is “why does the ice cube melt faster on block A?”

Two students’ answers are:

Student 1: the ice melts faster on block A because block A is a good conductor. Although block A s colder than block B, it is still warmer than the ice. As cold moves into block A, the ice warms up and melts. The ice on block A melts faster because the cold moves from the ice into this block faster.

Student 2: the ice melts faster on block A because metal absorbs cold. Block A absorbs cold from the ice which causes the ice to get warmer and melt. This is why block A feels colder than block B; it absorbs and holds more cold energy.

Which answer would you credit more and why?

B. NEW COURSE PROPOSAL

MIDDLE EAST TECHNICAL UNIVERSITY
Graduate School of Social Sciences
Department of Elementary Education

1. **Course Code, Title and Credit:**

8220510, Argumentation in Science Teaching and Learning (3-0) 3

2. **Catalog Description:**

Argumentation in science and science education; Strategies for defining and supporting argumentation; Written argumentation; Practical inquiry and argumentation; Argumentation in socio-scientific contexts; Exploring assessment related to argumentation.

3. **Frequency:** Fall Semesters; Spring Semesters.
4. **Given By :** Prof. Dr. Jale ÇAKIROĞLU, and Res. Assist. Yasemin Ozdem

5. **Background Requirements:**

Methods of science teaching; Instructional theories of education; Classroom culture; Communities of Practice; Laboratory applications in science education; Assessment in science education.

6. **Complementing/overlapping Courses:**

The course complements the courses on the domains of teaching science and mathematics offered in the master program in the Department of Elementary Education. The specific course that the offered course complements is ESME 560 Analysis of Research in Elementary Mathematics and Science Education. This course briefly refers to the discourse and argumentation in science education, however, the emphasis is not on all dimensions of discourse and argumentation including argumentation in socio-scientific contexts, written argumentation frameworks, and/or assessment of/in argumentation, major constructs which are indispensable parts of science and influence teaching and learning in science classrooms where discourse is part of teaching and learning process.

Therefore, the proposed course will complement this course in terms of providing a broad scope of argumentation theory in science education both theoretically and practically.

7. Course in relation to the programs:

i) **the particular program** slot into which the course is intended to fit: Elementary Science and Mathematics Education Master Program in the first four semesters in which students are expected to enroll in elective courses and choose their field of concentration as well as master thesis topic. The course also fits the Elementary Education Doctoral Program in the 1st and 2nd semesters in which students are expected to enroll in elective courses and not yet determined their dissertation topic.

ii) **the gap in the programs** (disciplinary and/or interdisciplinary**)** to fill, **the basic purpose** to serve, etc.: The course is expected to provide the master students with an in-depth study of argumentation in the graduate programs in the Department of Elementary Education. Although the department focuses on Discourse & Argumentation in Science Classrooms through an analysis of research, argumentation has not been addressed in-depth. Argumentation has been a concern of graduate students through their master's thesis and doctoral dissertations in the graduate programs in the Department of Elementary Education. However, graduate students who conducted these studies and those who want to conduct research on the dimensions of argumentation or argumentation theory did not have any intense study about the classroom interventions of argumentation practices and assessment in/of argumentation through a graduate course. Therefore, the course intends to provide graduate students with the intense study about argumentation in science education. It is aimed that the graduate students will elaborate on the course experiences during their graduate studies or further research in their career.

8. Course Objectives:

Itemize, with brief, explicit and precise statements, the specific skills, capabilities, views, insight, knowledge, etc. **the student is expected to acquire** by way and **at the end of the course;** state only those most pertinent.

1. to draw from existing literature to contextualize the role of argumentation in science and in science education;
2. to identify some of the pedagogical strategies necessary to promote argumentation skills in science lessons;
3. to trial the pedagogical strategies and to determine the extent to which their implementation enhances their pedagogic practice with argumentation;

4. to provide students some example guidelines for structuring the lessons in ways that would support evidence-based reasoning to take place;
5. to generate some example resources that can be useful for elementary science teachers to link ideas on scientific argumentation with coursework that includes practical investigations;
6. to generate some strategies for and criteria of assessment of argumentation in science lessons;
7. to develop an interest in research on argumentation in science education.

9. Course Outline:

Week	Topics and/or Phases
1	First Meeting
2	Introduction to the web-based support system for a teacher training program that will be used throughout the term
3	Communication and persuasion: the importance of integrating communication and persuasion activities in science lessons as well as the necessity of exposing and engaging students in a range of communicative actions.
4	1. Introduction to argumentation 1.1. Defining argumentation 1.2. The importance and role of argumentation in science and science education 1.3. Introduction to argumentation in the context of scientific inquiry
5	2. Strategies for defining and supporting argumentation 2.1. A diagram of Toulmin's argumentation pattern 2.2. Analysis of a series of excerpts taken from elementary science textbooks to identify argument patterns. 2.3. Pedagogical strategies and ways in which argumentation can be used
6	2.4. Supporting students in identifying, understanding and using evidence. 2.5. How to enhance scientific argumentation by posing open questions: A set of arguing prompts 2.6. Design of a learning for promoting argumentation: Designing lesson plan and resources that consist of argumentation
7	Sharing teaching practices Example teaching practices and reflections on lessons
8	3. Written argumentation 3.1. Supporting writing argument 3.2. Mapping written argument framework

Week	Topics and/or Phases
	3.3. Science Writing Heuristic as a written argumentation framework
9	4. Practical inquiry and argumentation 4.1. Linking practical work in science with argumentation 4.2. Teachers' roles in inquiry and argumentative learning environments: *guiding and modeling scientific inquiry.*
10	4.3. How teachers support particular students' roles and practices, focuses on inquiry and argumentation: *helping students to design and carry out investigations.* 4.4. A model of teaching and learning that focuses on inquiry and argumentation: Argument-driven inquiry
11	5. Argumentation in socio-scientific contexts 5.1. Exploration of how argumentation and discourse could be used in the context of science-technology-society or socio-scientific issues 5.2. A jig-saw activity related to gene therapy
12	6. Exploring assessment related to argumentation 6.1. Exploring assessment criteria for argument 6.2. Assessment in argumentation 6.3. Assessing argumentation: How Toulmin's model can be transformed for purposes of assessment
13	Design of a learning for promoting inquiry and argumentation: designing lesson plan and resources that consist of authentic scientific inquiry
14	Sharing teaching practices and reflections on lessons Evidence-based professional development portfolios

10. Textbooks:

Erduran, S., & Jiménez-Aleixandre, M. P. (2008). *Argumentation in science education: Perspectives from classroom-based research.* Dordrecht: Springer.

Boersma, K., Goedhart, M., de Jong, O., & Eijkelhof, H. (2005). *Research and the quality of science education. "Part 7: Discourse and argumentation in science education".* Springer.

11. Reference Material:

Berland, L. K., & McNeill, K. L. (2010). A learning progression for scientific argumentation: Understanding student work and designing supportive instructional contexts. *Science Education, 94*(5), 765-793.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the Norms of Scientific Argumentation in Classrooms. *Science Education, 84*(3), 287-312.

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's Argument Pattern for studying science discourse. *Science Education, 88*(6), 915-933.

Hand, B., Norton-Meier, L., Staker, J., & Bintz, J. (2009). *Negotiating Science The Critical Role of Argument in Student Inquiry, Grades 5-10."Introduction to the Science Writing Heuristic (SWH) Approach".* Portshmouth, NH: Heinemann.

Kelly, G. J. (2005). Discourse, Description, and Science Education. In Yerrick, R. & Roth, W-M. (Eds.). *Establishing scientific classroom discourse communities: Multiple voices of* teaching *and learning research* (pp. 79-104). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Kelly, G. J., & McDonald, S. P. (2012). Beyond Argumentation: Sense-Making Discourse in the Science Classroom. In Khine, M.S.S. (Ed.). *Perspectives on Scientific Argumentation Theory, Practice and Research* (pp. 265-281). Netherlands: Springer.

McNeill, K. L. (2009). Teachers' use of curriculum to support students in writing scientific arguments to explain phenomena. *Science Education, 93*, 233-268.

Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching, 41*, 513–536.

Sampson, V., & Clark, D. B. (2008). Assessment of the ways students generate arguments in science education: Current perspectives and recommendations for future directions. *Science Education, 92*, 447-472.

Sampson, V., Grooms, J., & Walker, J. P. (2011). Argument-driven inquiry as a way to help students learn how to participate in scientific argumentation and craft written arguments: An exploratory study. *Science Education, 95*, 217-257.

Simon, S., Erduran, S., & Osborne, J. (2006). Learning to teach argumentation: Research and development in the science classroom. *International Journal of Science Education, 28*(2), 235-260.

Zembal-Saul, C. (2009). Learning to teach elementary school science as argument. *Science Education, 93*, 687-719.

12. Course Conduct:

The main methods by means of which the course is to be conducted are through:

- the presentations and discussions of articles and/or texts assigned,
- in class and out of class practical applications, such as hands-on/ minds-on in class activities and examples of out-of class lectures

- sharing teaching practices and reflections on lessons videotaped, and
- preparation of evidence-based professional development portfolios.

13. Grading:

The principal means by which student performance is to be evaluated are:

- active participation in class discussions and activities,
- sharing teaching practices and reflections on lessons,
- engagement in class discourse by means of pre-prepared questions, and
- preparation of evidence-based professional development portfolios; including learners' perspectives about each article/ reading, sample lesson plans, learners' class work, homework and assignments, interview transcripts of learners talking about their learning, commentaries that explained how the collection of artifacts showed development, sample student work from their practical applications, and a synthesizing paper about argumentation studies/ applications in Turkish context.

14. Effective Date:

Spring of 2011-2012 Year

15. Faculty Member:

Prof. Dr. Jale ÇAKIROĞLU

Course accepted by Graduate Committee / Departmental Academic-Board in meeting held on……../….../……

Signature

Head of Department

C. PLANNED TASKS FOR THE COURSE

Wk	Topics and/or Phases	Readings/ Articles	Pre-Activity Discussion	Activity	Post-Activity Discussion	Materials to be used
1	First Meeting	none	none	none	none	Syllabus
2	Introduction to the web-based support	none	none	Introduction to the web-based support system (WBSS) for a teacher training program	Questions related to the WBSS	WBSS

Wk	Topics and/or Phases	Readings/ Articles	Pre-Activity Discussion	Activity	Post-Activity Discussion	Materials to be used
3	Communication and persuasion	* Article: Kelly, G. J. (2005) * Optional: Kelly, G. J., & McDonald, S. P. (2012); Scott & Mortimer (2005)	-Do we have a problem of communicating scientific ideas in our science classrooms? -Do students know how to write a sound scientific claim or how to draw conclusions based on collected data? -What do students need to know to communicate scientific ideas? -What should be the feature of a productive group discussion?	* video-watch on the examples of students' communication and persuasion in science classrooms. *video-watch on discourse episodes	-Why students should be encouraged to talk about scientific ideas? -What strategies do teachers use to engage students in discourse?	*video numbered 09_01- pupils' work *Discourse episodes on the IDEAS video

Wk	Topics and/or Phases	Readings/ Articles	Pre-Activity Discussion	Activity	Post-Activity Discussion	Materials to be used
4	Introduction to argumentation	* Article: Driver, R., Newton, P., & Osborne, J. (2000) * Optional: Osborne, J. (2005)	-What do you think as scientific knowledge? -As teachers how do you judge an idea whether as scientific or not? -How do you describe argumentation? - What do you think about the feature/components of a meaningful/ strong argument are? (What makes a good argument) -What do you think about the role of argumentation, as distinctive, in science & science education?	*video-watch on Steve's 'Runny Honey' Lesson *What are the components of an explanation supported by evidence? (A1) *Analysis of a series of excerpts taken from elementary science textbooks to identify argument patterns	-Why identification of evidence is important? -Can you compare your components of argument with Toulmin's? What are the pros and cons of Toulmin's Argumentation Pattern? -What do you think about the applications of Toulmin's argumentation pattern in students' discourse?	* video from the 'Mind the Gap' Resources: Steve's 'Runny Honey' Lesson * Toulmin's argument pattern *Simon's presentation of the use of Toulmin's argumentation components *worksheet A1 (resources)

Wk	Topics and/or Phases	Readings/ Articles	Pre-Activity Discussion	Activity	Post-Activity Discussion	Materials to be used
5	Strategies for defining and supporting argumentation	* Article: Berland, L. K., & McNeill, K. L. (2010) * Optional: Erduran, S., Simon, S., & Osborne, J. (2004)	-How do you think the discourse among students affects students' learning? -What do you need to take account when planning and implementing discourse? -Do you think argumentation have an impact on students' science learning? -How would you plan to integrate argumentation into your science lessons?	*Brainstorming some of the ways in which pedagogical strategies could support argumentation in science teaching *Pedagogical strategies activities taken from Tumay (2011).	-Do you think that argumentation is an effective strategy to teach science concepts? -Do you think that argumentation should be integrated into the science classrooms? -Plase try to suggest another strategy to integrate argumentation into science lessons.	*pedagogical strategies slide *concept cartoons: IDEAS act.11 *competing theories: IDEAS act. 6 *sequencing: IDEAS act. 10 *ranking: IDEAS act. 8 *graphs : IDEAS act. 13 * role play: IDEAS act. 2

Wk	Topics and/or Phases	Readings/ Articles	Pre-Activity Discussion	Activity	Post-Activity Discussion	Materials to be used
6	Supporting students in identifying, understanding and using evidence.	* Article: Simon, S., Erduran, S., & Osborne, J. (2006) * Optional: Zembal-Saul, C. (2009)	-How are knowledge claims weighted? -What do you think about the role of evidence in science and science edc? -What do you count as evidence in scientific arguments? -Which practices do we have in mind when talking about students' use of evidence?	* How do we know what we know? * Activity 2: Holiday in Dubai * Excerpts from students' discourse and evaluation of them in terms of evidence *Arguing prompts revisited. *Design of a learning	-What other strategies could be useful in supporting students in identifying, understanding and using evidence? - What other strategies could be useful in enhancing scientific argumentation?	*How do we know evidence worksheet * IDEAS introduction to arg. Resources *Santiago resources doc.2 * Bonding Chemistry and Argument activity booklet (Act.2 worksheets)

Wk	Topics and/or Phases	Readings/ Articles	Pre-Activity Discussion	Activity	Post-Activity Discussion	Materials to be used
7	Sharing teaching practices- Example teaching practices and reflections on lessons	none	-Review the video-taped lessons and/or resources in terms of *pedagogy, *classroom management, *ideas on how these lessons can be used in their own school,	* reflections on their teaching *reflections on sample teachings	-How do you manage your science classrooms when pupils are role playing/experimenting/discussing in an argumentation-based activity? -How did/can you enable pupils to share their ideas? -Why did you teach this particular practical with a certain class?	Teachers' descriptions of 1. The Hearing Loss Lesson; 2. The Wind Farms Lesson (APISA booklet)
8	Written argumentation	* Article: Hand, B., Norton-Meier, L., Staker, J., & Bintz, J. (2009) * Optional: McNeill, K. L. (2009)	- Do you think is it necessary to support writing arguments? Why? -How can you support students in writing argument? - Try to map a written argument framework.	*mapping a written argument framework *evaluation of written examples of students' work *a written argumentation exercise *video-watch on an SWH exercise	- How effective do you think writing frames in science? -Can you adapt other writing frameworks which supports different components of an argument?	* writing frames (Simon & Johnson) *IDEAS pack of written arguments and verbal transcripts *written examples of students' work (Sampson's presentation)

Wk	Topics and/or Phases	Readings/ Articles	Pre-Activity Discussion	Activity	Post-Activity Discussion	Materials to be used
9	Practical inquiry and argumentation	* Article: Sampson, V., Grooms, J., & Walker, J. P. (2011)	- Why do we carry out practical work? - How to provide students with opportunities to participate in authentic science? Or, in other words: What activities do students carry out when they are engaged in inquiry?	*Linking practical work in science with argumentation activity * “Does the moon influence plant growth?” activity	-Do you think that inquiry based learning environments serve good argumentation opportunities? Or, how inquiry based environments support argumentation? -Do you think other learning environments where argumentation can be integrated fruitfully?	*a series of worksheets illustrating practical activities *packs of post-it notes *Sampson’s presentation of argument-driven inquiry * “Does the moon influence plant growth?” activity worksheets

Wk	Topics and/or Phases	Readings/ Articles	Pre-Activity Discussion	Activity	Post-Activity Discussion	Materials to be used
10	How teachers support particular students' roles and practices, focuses on inquiry and argumentation	* Article: Jiménez-Aleixandre & Erduran (2008) Ch.5	-How can teachers support the engagement in argumentation during inquiry-based learning? -What should be the role of teacher and students in inquiry based learning environments in order to promote argumentation? -How can you support different components of argumentation?	*video-watch on argument based laboratory *integrating argumentation to a simple inquiry-based lesson plan	-What did you take account when you adapt argumentation strategies to inquiry based learning? -What do you think about the teachers' roles in inquiry and argumentative learning environments?	*video on argument based laboratory * a simple inquiry-based lesson plan

Wk	Topics and/or Phases	Readings/ Articles	Pre-Activity Discussion	Activity	Post-Activity Discussion	Materials to be used
11	Argumentation in socio-scientific contexts	* Article: Jiménez-Aleixandre & Erduran (2008) Ch.9 *Optional: Sadler, T. D. (2004)	-How argumentation and discourse could be used in the context of science-technology-society or socio-scientific issues? - How to provide students with opportunities to participate in decision-making in science? Or, in other words: What activities do students carry out when they are engaged in decision-making?	* video-watch on argumentation in socio-scientific context *A jig-saw activity related to gene therapy	-Do you think that socio-scientific contexts serve good argumentation opportunities? Or, how socio-scientific contexts support argumentation? -What do you think about the teachers' roles in argumentation about socio-scientific issues?	* video on argumentation in socio-scientific context *jig-saw activity worksheets

Wk	Topics and/or Phases	Readings/ Articles	Pre-Activity Discussion	Activity	Post-Activity Discussion	Materials to be used
12	Exploring assessment related to argumentation	* Article: Sampson, V., & Clark, D. B. (2008)	- Which assessment strategies do you use in your science classrooms? - How do different aspects of assessment have implications for assessing argumentation in science classrooms? -How the quality of argumentation can be assessed in particular in spoken discussions in the classroom?	*Using examples from your own lesson plans, choosing examples of lessons that would target different aspects of assessment. *Activity 1. Halloween Crush *work in groups to identify a short video clip from their classroom discussions, and use the levelling framework to identify some examples. *identify some written work of their pupils and identify features of arguments.	- What potential strategies can you offer for promoting disagreement in group discussions so as to ensure that rebuttals can emerge?	*Levels of argument framework by Erduran et al (2004) *Erduran & Villamanan's (2009)use of TAP in written arguments *Activity 1 worksheets *IDEAS video clip 25, 26, 27

Wk	Topics and/or Phases	Readings/ Articles	Pre-Activity Discussion	Activity	Post-Activity Discussion	Materials to be used
13	authentic scientific inquiry, argumentation and assessment of argumentation	none	none	* Design of a learning for promoting high quality argumentation, and assessment of argumentation	Questions from learners	* curriculum *pedagogical strategies handout *writing frames handout * TAP levels handouts
14	Sharing teaching practices and reflections on lessons Evidence-based professional development portfolios	none	-Review the video-taped lessons and/or resources in terms of *pedagogy, *classroom management, *ideas on how these lessons can be used in their own school, *feedback to the group their ideas for development	* reflections on their teaching *reflections on sample teachings	-How do you manage your science classrooms in an argumentation-based activity? -How did you enable pupils to share their ideas? -Why did you teach this particular practical with a certain class? -What do you trying to achieve with these lessons in terms of argumentation in science?	* Learners' their own video-records of science lessons through argumentation

D. POST-INTERVIEW QUESTIONS

Thank you for taking time to have an interview with me today. This interview will probably take about 20-30 minutes to complete. As I mentioned to you before, we are doing these interviews with the graduates of science education and enrolled in the course ‘Argumentation in Science Teaching and Learning’. The information from these interviews will be pulled together and used to inform my PhD study which is about argumentation, and to improve the professional development and support provided by the course. This interview will be used for this purpose only and will be confidential, that is I will not identify you by name in the report or in any conversations with other people.

1. Based on your understanding during the course, how can you describe argumentation?

2. Could you please describe your understanding about rebuttals? Why is it important to include a rebuttal in an argument?

3. Could you please describe your understanding about counter argument? Why would you include a counter-argument in argumentation?

4. What do you think about the instructional strategies related to argumentation that you have seen during the course and implemented in real classroom setting?

5. Which aspects of argumentation were effectively taught and learned during the course? Which activities and/or topics related to argumentation you find effective/ useful/ feasible and worth to learn and teach?

6. Do you feel yourself adequate to teach science through argumentation and to teach argumentation?

7. What do you think about the practical applications of argumentation theory in real classroom settings? To what extent the theory and practice are consistent?

8. Which statement provides the strongest support for the claim that “day and night are caused by spinning Earth”?

a. The stars appear to move in a counter clockwise circular direction around Polaris as the approximate centre

b. There is seasonal change in the Sun's altitude at noon and its daily duration in the sky

c. There are monthly phases of the Moon

d. Seasonal transition times vary: spring to summer 92 days, summer to fall 94 days, fall to winter 90 days, winter to spring 89 days.

9. The case is that: There are two blocks: Block A and Block B. They are not identical. The blocks are at room temperature. The teacher places two identical ice cubes on these blocks. Students observe in a while that the ice cube on Block A melts faster than the ice cube on Block B. The students were asked "why does the ice cube melt faster on block A?" and defend their argument with appropriate evidence and reasoning.

Two students' answers are:

Student 1: I know this because watching the ice melt, I was able to see that block A transferred the most energy. This cold energy from the ice transferred to the metal because the metal of block A is a good conductor. When block A was heated and chilled, it happened much faster and more drastically than the plastic block B. When the oven was at 60^0C, the block A was at 54.6^0C compared to the block B that was at 53.1^0C at the same oven temperature. There were similar results when the blocks were placed in the freezer.

Student 2: the temperature at block A is 22.9^0C, colder than block B which is 23.1^0C which shows that block A can absorb more cold than block B. When we put in the freezer block A cooled faster than block B. This shows that block A absorbed the cold from the ice faster than Block B causing the ice on block A to melt faster than the ice on block B. Block A also absorbs heat quicker than block B showing that the energy in block A moves faster than the energy in block B.

10. What suggestions can you make for the next semester?

E. SYLLABUS

MIDDLE EAST TECHNICAL UNIVERSITY/ FACULTY OF EDUCATION

ESME 510

Argumentation in Science Teaching and Learning

Time: Wednesday 9: 00-11:30 **Room:** EF-106

Instructor: Prof. Dr. Jale Çakıroğlu **Res. Assist:** Yasemin Özdem

E-mail: jaleus@metu.edu.tr **E-mail:** yozdem@metu.edu.tr

Course Goals

This course is designed to provide students a study on the current state of theory and research on argumentation in school science. There will be a review of selected studies that try to synthesize the research movements about argument in science education.

This is a participatory learning class. That means that your absence effects the learning of others. Consequently, missing classes significantly affects your grade. Missing more than two classes will significantly impact your class participation grade. Attendance is required. Attendance requires *preparation.*

The specific skills, capabilities, views, insight, knowledge that you are expected to acquire by way and at the end of the course;

1. to draw from existing literature to contextualize the role of argumentation in science and in science education;
2. to identify some of the pedagogical strategies necessary to promote argumentation skills in science lessons;
3. to trial the pedagogical strategies and to determine the extent to which their implementation enhances their pedagogic practice with argumentation;
4. to provide students some example guidelines for structuring the lessons in ways that would support evidence-based reasoning to take place;
5. to generate some example resources that can be useful for elementary science teachers to link ideas on scientific argumentation with coursework that includes practical investigations;

6. to generate some strategies for and criteria of assessment of argumentation in science lessons;
7. to develop an interest in research on argumentation in science education.

Main Texts

Erduran, S., & Jiménez-Aleixandre, M. P. (2008). *Argumentation in science education: Perspectives from classroom-based research.* Dordrecht: Springer.

Course Conduct:

The main methods by means of which the course is to be conducted are through:

- the presentations and discussions of articles and/or texts assigned,
- in class and out of class practical applications, such as hands-on/ minds-on in class activities and examples of out-of class lectures
- sharing teaching practices and reflections on lessons videotaped, and
- preparation of evidence-based professional development portfolios.

Course Activities and Corresponding Grades:

The principal means by which your performance will be evaluated are:

- ***active participation in class discussion/ activities (%15) and engagement in class discourse by means of pre-prepared questions (%10):*** We expect you to engage in informed, thoughtful class discussions, demonstrate effective listening, critically examine ideas and concepts, and attend class regularly. We expect everyone to engage actively in discussions. It is critical that you come to class having thoroughly read and studied the material and be able to contribute to an insightful discussion of it.

  Everyone will help the discussion of the week by sending the class discussion questions *(at least 3) based* on the reading of the week by every **Monday** evening until 5 pm. Please send your discussion questions to instructor and research assistant as well.

- ***sharing teaching practices and reflections on lessons (%30):***

Teaching practices will be examples of your teaching in a real elementary science classroom. The school you will teach at might be the school you already work at, a school that you agreed to attend for teaching practice, a school that as the course coordinators we arranged for you to practice. In case that there are no school teaching practice opportunity, you can do a micro-teaching in our classroom if you notify us earlier enough.

- ***preparation of evidence-based professional development portfolios (%45):*** you are expected to prepare a course portfolio including
  - ***your perspectives about each article/ reading(%10):*** All students will be required to write brief reflection papers for each week's lecture and video-record at least 2 teaching practices during the course. You can prepare your reflections by selecting a specific portion of a subtopic from a main topic/chapter. Reflection papers should be at least 600 (about 600-700 words) words entered through an online reflection page on learning design portal. **Reflection papers will be submitted after the day of presentation (Wednesday)**. **No reflection paper will be accepted if you were absence from the class.**
  - ***sample lesson plans(%15)***
  - ***sample student work from your practical applications(%10)***
  - ***Personal Statement of Argumentation in Schools (%10):*** On three occasions (indicated on the tentative schedule) during the semester, you will submit a statement of your current view of the argumentation in schools and how should schools approach to this issue

Academic Ethics and Plagiarism:

All assignments you hand in should be the result of your effort only. Academic dishonesty, including any form of cheating and plagiarism will not be tolerated and will result in failure of the course and/or formal disciplinary proceedings usually resulting in suspension or dismissal. Cheating includes but is not limited to such acts as; offering or receiving unpermitted assistance in the exams, using any type of unauthorized written material during the exams, handing in any part or all of someone else’s work as your own, copying from the Internet. Plagiarism is a specific form of cheating. It means using someone else’s work without giving credit. Plagiarism is a literary theft. Therefore, you have to acknowledge the sources you use in your assignments.

Tentative Schedule

Week	Course Content	Assignment
Week 1 September, 26	First Meeting	
Week 2 October, 7	1. Introduction to argumentation 1.1. Defining argumentation 1.2. The importance and role of argumentation in science and science education	* Article: Driver, R., Newton, P., & Osborne, J. (2000) Optional: Erduran, S., & Jiménez-Aleixandre, M. P. (2008) Chapter 1. * 3 questions related to the article(s) * learners' perspectives about each article/ reading *** personal statement about argumentation**
Week 3 October, 10	2. Strategies for defining and supporting argumentation 2.2. Pedagogical strategies and ways in which argumentation can be used	* Article: Berland & Hammer (2012) and PhD thesis: Tümay, H. (2008) * Optional: Erduran, S., Simon, S., & Osborne, J. (2004) * 3 questions related to the article(s) * learners' perspectives about each article/ reading
Week 4 October, 31	2.3. Supporting students in identifying, understanding and using evidence. 2.6. Design of a learning for promoting argumentation: Designing lesson plan and resources that consist of argumentation	* Article: Khishfe (2012) * Optional: Simon, S., Erduran, S., & Osborne, J. (2006) Zembal-Saul, C. (2009) * 3 questions related to the article(s)
Week 5 November, 7	3. Written argumentation 3.1. Supporting writing argument 3.2. Mapping written argument framework 3.3. Science Writing Heuristic as a written argumentation framework	* learners' perspectives about each article/ reading * Article: Hand, B., Norton-Meier, L., Staker, J., & Bintz, J. (2009) * Optional: McNeill, K. L. (2009) * 3 questions related to the article(s) *** personal statement about argumentation**

Week	Course Content	Assignment
Week 6 November, 14	Sharing teaching practices Example teaching practices and reflections on lessons	* 1st sample lesson plan (argumentation integrated) * learners' reflection on their learning progression
Week 7 November, 21	4. Practical inquiry and argumentation 4.1. Linking practical work in science with argumentation 4.4. A model of teaching and learning that focuses on inquiry and argumentation: Argument-driven inquiry	* learners' perspectives about each article/ reading * Article: Sampson, V., Grooms, J., & Walker, J. P. (2011) * Optional: * 3 questions related to the article(s)
Week 8 November, 28	4.2. Teachers' roles in inquiry and argumentative learning environments: guiding and modeling scientific inquiry. 4.3. How teachers support particular students' roles and practices, focuses on inquiry and argumentation: helping students to design and carry out investigations.	* learners' perspectives about each article/ reading * Article: Sampson & Blanchard (online) * 3 questions related to the article(s)
Week 9 December, 5	5. Argumentation in socio-scientific contexts 5.1. Exploration of how argumentation and discourse could be used in the context of science-technology-society or socio-scientific issues 5.2. Social interaction in argumentation 5.3. An activity related to biodegradable bags	* Article: Sadler, T. D. (2004) * Optional: Oliveira, Akerson, & Oldfield (2012) * 3 questions related to the article(s) * learners' perspectives about each article/ reading
Week 10 December, 12	6. Exploring assessment related to argumentation 6.1. Exploring assessment criteria for argument 6.2. Assessment in argumentation 6.3. Assessing argumentation: How Toulmin's model can be transformed for purposes of assessment	* learners' perspectives about each article/ reading * Article: Sampson, V., & Clark, D. B. (2008) * 3 questions related to the article(s) * 2nd sample lesson plan (argumentation integrated)
Week 11 December, 19	Sharing teaching practices Example teaching practices and reflections on lessons	* learners' reflection on their learning progression *** personal statement about argumentation**
Week 12 December, 26	Design of a learning for promoting inquiry and argumentation: designing lesson plan and resources that consist of authentic scientific inquiry	* 3rd sample lesson plan (argumentation integrated) * learners' reflection on their learning progression

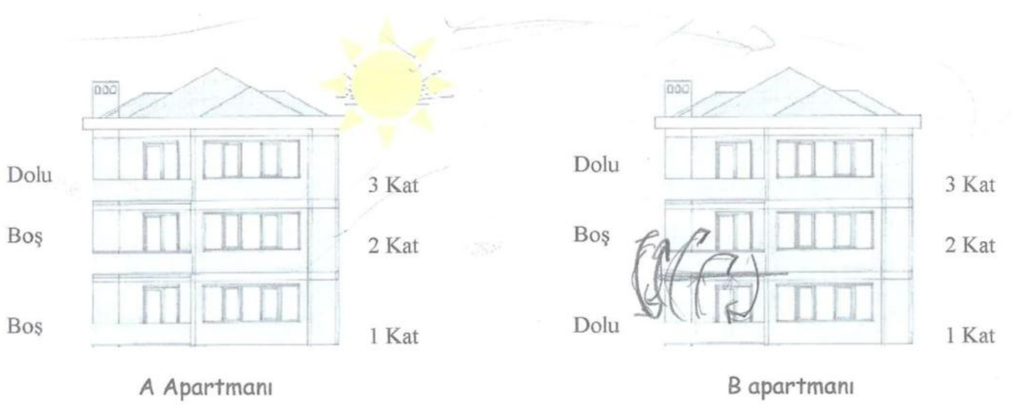
F. SAMPLE STUDENT WORKSHEETS

Figure F-1 A student groups' worksheet in Can's first teaching class

ETKİNLİK KAĞIDI

ISININ İLETİLMESİ

Lütfen aşağıda verilen resmi dikkatle inceleyiniz.



A apartmanında ikinci ve üçüncü kattaki daireler, B apartmanında ise ikinci kattaki daire boştur. A apartmanındaki daireler gündüz güneş alırken, B apartmanındaki daireler güneş almamaktadır. Dolu dairelerin hepsi doğalgaz ile ısınmaktadır.

Bir kiracı boş olan üç daireden hangisini kiralarsa kış gecelerinde daha az yakıt harcayarak daha iyi ısınabilir?

BİZİM DÜŞÜNCEMİZ:

B ..A.. apartmanındaki ...2....kattaki dairenin kış gecelerinde daha az yakıt harcayarak daha iyi ısınabileceğini düşünüyoruz.

Çünkü...A apt gündüz ışık alırken B apartmanı alamıyor.
Akşam olduğunda ise B apt güneş alıyor.
Bu sayede ışıma yoluyla ısınıyor.

Figure F 1 (cont) A student groups' worksheet in Can's first teaching class

Aşağıda düşüncenizi destekleyebilmeniz için size yardımcı olabilecek ipucu kartları verilmiştir. Bu ipucu kartlarını okuyunuz. Hangi ipucu kartlarının sizin düşüncenizi destekleyeceğini grubunuzda tartışınız.

İPUCU KARTLARI:

1	Maddeler tanecikli yapıdan oluşur.
2	Gaz tanecikleri bulundukları ortamın doldururlar.
3	Katı maddelerde ısı taneciklerin birbirine çarpması ile iletilir
4	Isının iletim yoluyla aktarılması katılarda kolay, gazlarda ve sıvılarda daha zordur.
5	Isıyı ileten maddelere ısı iletkeni denir.
6	Isınan gaz ve sıvı taneciklerin yoğunluğu azalır.
7	Isının akış yönü sıcak olan maddeden soğuk olan maddeye doğrudur.
8	Güneş ışıma yoluyla ısı yayar.
9	Açık renkli yüzeyler koyu renkli yüzeylere göre üzerlerine gelen ışınları daha az yansıtırlar.
10	Isınan hava yukarı çıkar.
11	Maddeler ısı aldığına tanecikleri daha yavaş hareket eder.

konveksiyon

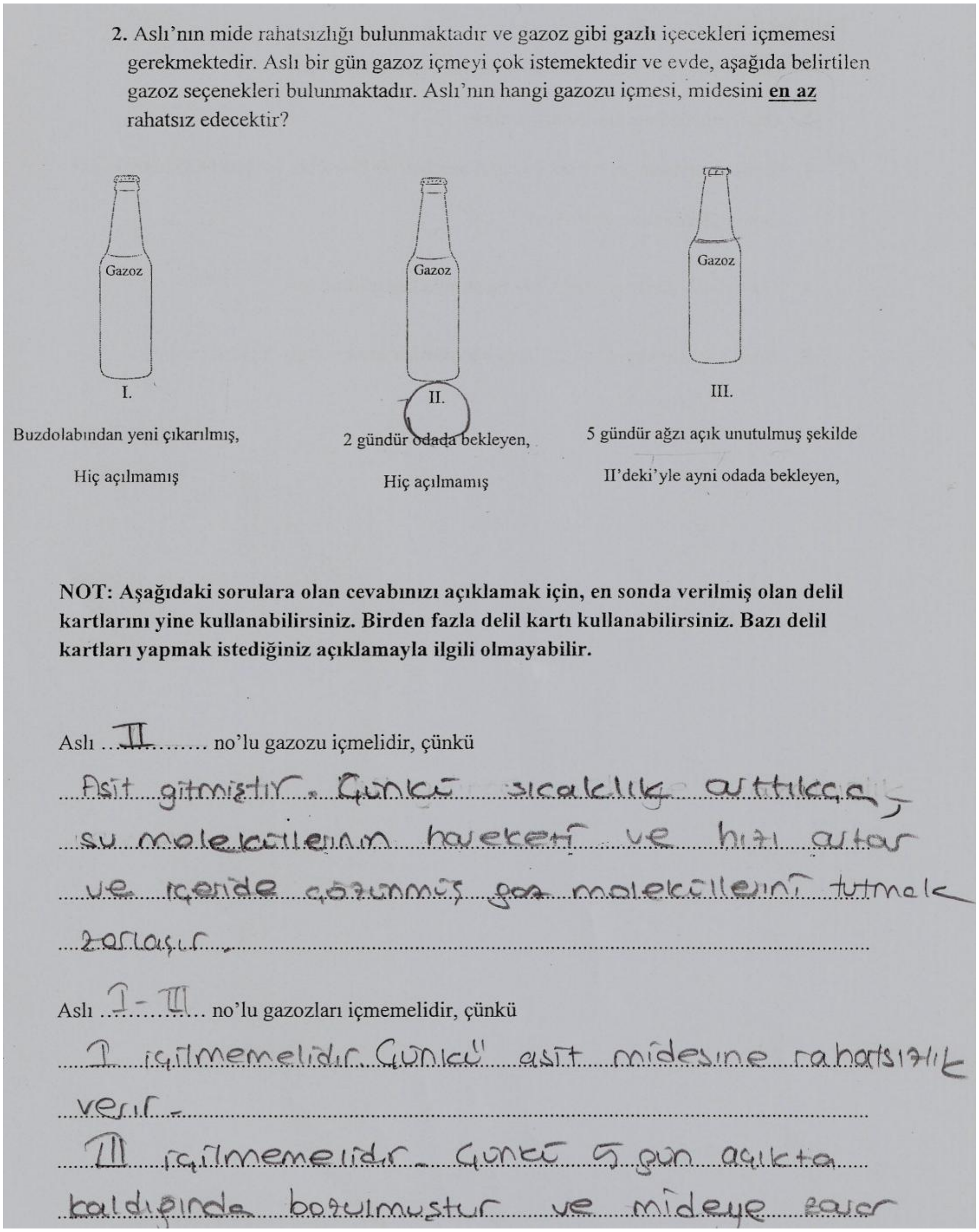
Düşüncemizi desteklemek için YARARLANDIĞIMIZ İPUCU KARTLARI:

6-8-10 numaralı ipucu kartlarını bizim düşüncemizi desteklemek için kullanabiliriz. **ÇÜNKÜ;** bulduğumuz cevap ısının ışıma ve konveksiyon yoluyla yayılmasıyla ilgilidir.

DİĞER DÜŞÜNCELERE KATILMIYORUZ ÇÜNKÜ;

A 2 'nin 3. katı boş olduğu için daha fazla

Figure F-1 A student groups' worksheet in Asya's first teaching class



2. Aslı'nın mide rahatsızlığı bulunmaktadır ve gazoz gibi gazlı içecekleri içmemesi gerekmektedir. Aslı bir gün gazoz içmeyi çok istemektedir ve evde, aşağıda belirtilen gazoz seçenekleri bulunmaktadır. Aslı'nın hangi gazozu içmesi, midesini **en az** rahatsız edecektir?

Gazoz | Gazoz | Gazoz

I. Buzdolabından yeni çıkarılmış, Hiç açılmamış

II. 2 gündür odada bekleyen, Hiç açılmamış

III. 5 gündür ağzı açık unutulmuş şekilde II'deki'yle ayni odada bekleyen,

NOT: Aşağıdaki sorulara olan cevabınızı açıklamak için, en sonda verilmiş olan delil kartlarını yine kullanabilirsiniz. Birden fazla delil kartı kullanabilirsiniz. Bazı delil kartları yapmak istediğiniz açıklamayla ilgili olmayabilir.

Aslı ...II...... no'lu gazozu içmelidir, çünkü

Asit gitmiştir. Çünkü sıcaklık arttıkça, su moleküllerinin hareketi ve hızı artar ve içeride çözünmüş gaz moleküllerini tutmak zorlaşır.

Aslı ...I - III... no'lu gazozları içmemelidir, çünkü

I içilmemelidir. Çünkü asit midesine rahatsızlık verir.

III içilmemelidir. Çünkü 5 gün açıkta kaldığında bozulmuştur ve mideye zarar

G. CURRICULUM VITAE

PERSONAL INFORMATION

Name	: Yasemin Özdem Yilmaz
Date of birth	: 01.09.1982/ Eskişehir
Nationality	: Türkiye
Tel	: +90 (312) 210 4059
Fax	: +90 (312) 210 7984
E-mail	: yozdem@metu.edu.tr / yasemin.ozdem@hotmail.com

EDUCATION

Visiting Scholar	**Graduate School of Education** Bristol University	Febr-June 2013
PhD	**Elementary Education** Social Sciences Institute/Faculty of Education Middle East Technical University, Ankara/Türkiye	2009-2014
Master	**Elementary Science and Mathematics Education** Social Sciences Institute/Faculty of Education Middle East Technical University, Ankara/Türkiye	2007-2009
Bachelor	**Elementary Science Education** Elementary Education Department/ Faculty of Education Middle East Technical University, Ankara/Türkiye	1998-2003

EXPERIENCE

Research Assistant	**Faculty of Education / Dep. Elementary Education** Middle East Technical University, Ankara/Türkiye	2008 – cont
Science Teacher	**MEB Kâtip Çelebi İlköğretim Okulu** Fatih/İstanbul/Türkiye Tel: +90(212) 5214958	2007-2008

	MEB Tınaztepe İlköğretim Okulu Bala/Ankara/Türkiye Tel: +90(312) 8761009	2006-2007
	Bahçeşehir Uğur Eğitim Kurumları Uğur Dershanesi Ankara Şubesi Necatibey Cad /Ankara/Türkiye	2006
	Charles W. Eliot Junior High School District of Columbia Public Schools Washington, DC 20002, USA	2005-2006
	UKnow Educational Institution 1301 Connecticut Avenue NW, Suite 800, Washington, DC 20036, USA	2005-2006
	MEB Çağla İlköğretim Okulu Kıbledağı Köyü/Güneysu/Rize/Türkiye Telefon: +90 (464) 394 8004	2004-2005
	Özel Ege Lisesi İlköğretim Okulu 119/1 sk. No: 3 Bornova 35050	2003-2004
Education Advisor	**CAMPUS Yurtdışı Eğitim Danışmanlığı** Bestekâr Sk. 82/3 Kavaklıdere Ankara/Türkiye Telefon: +90 (312) 4680030	2006

PROJECTS

2012-2013

- **Project Advisory Board Member- Educator**
  "The effects of Climate Change and Raising Awareness for Adapting Climate Change", Ministry of Environment and Urban Planning in Turkey and TUSSİDE cooperation, (2012-2013). http://www.iklimdegisikligineuyum.org/iklim/

- **Executive Board Member**
  EU 7th Framework Programme- Marie Curie Actions Researchers' Night 2012 FuLL-Science Project FP7-People-2012-Night. Grant agreement no.:31660 Coordinator: Assist. Prof. Dr. Bülent Çavaş, Dokuz Eylül University/ Faculty of Education

- **Educator**

  Çavaş, B., Özdem, Y. "Continuous Professional Development of Science and Technology Teachers PROFILES Project Workshop (Science Process Skills) 6. International Computing and Learning Technologies Symposium. Gaziantep (2012).

- **Researcher**

  Pre-service Science Teachers' Perceptions about Pseudo Science, Nature of Science and Evolution Theory (2012). University Supported Scientific Research Project (BAP1), No: BAP-05-06-2012-006, METU-BAP Coordination University: METU

2011

- **Researcher**

  "Evaluation of Pre- & In-service Science Teachers' and Elementary Students' Conceptual Knowledge about Earth Science and Their Attitudes towards Earth Science from an Ontological Perspective" 2011-2012. University Supported Scientific Research Project (BAP1), No: BAP-05-06-2011-001. METU-BAP Coordination

- **Researcher**

  EU- EACEA "Comenius-LD-Skills (Development of Learning Design Skills for Enhancing Students' Key Competencies)" Project, N°. 510276-LLP-1-2010-1-GR-COMENIUS CMP-LD-skills Coordinator: Assist. Prof. Dr. Bülent Çavaş

2010

- **Researcher- Educator**

  EU 7th Framework Programme PROFILES (Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science) Project. 5.2.2.1 – SiS- 2010- 2.2.1 Grant agreement no.: 266589, Duration: 4 Years Partner: Assist. Prof. Dr. Bülent Çavaş, Dokuz Eylül University/ Faculty of Education

2009

- **Symposium Executive Board Member**

  1st Science Symposium for Doctoral Researchers "Argumentation in Science Education" 29-30 August, Ahi Evran University, Kırşehir/Türkiye.

- **Researcher**

  "Teaching Nature of Science: A professional development project for science teachers about teaching scientific argumentation and reasoning based on History and

Philosophy of Science” TUBİTAK (The Scientific and Technological Research Council of Turkey) Project No: 1001/108K086

- **Mentor/ Educator**
  Cacabey Space Camp for Gifted Students and Their Science Teachers 22-28 June Kırşehir, Tükiye TÜBİTAK Project No: 4004/109B053.

2008

- **Researcher**
  “Investigating Pre-Service Science Teachers’ Scientific Literacy Levels and Their Attitudes towards Science” METU-BAP Coordination BAP-2008-07-03-00-12

- **Researcher**
  “Investigating the relationships among eight graders’ scientific literacy levels, attitudes towards science and reasoning ability” METU-BAP Coordination, BAP-2008-05-06-04

PROFESSIONAL DEVELOPMENT COURSES ATTENDED

2006

- **Language for Research Writing and Inquiry**
  DCPS Professional Development Institute Office of Academic Services Division of Curriculum and Instruction, USA Coordinator: Nathaniel Johnson Isong, Ph. D.

- **Differentiated Instruction & Classroom Management**
  UKnow Educational Institute, USA Coordinator: Jaime Willis, Vice Principal

2005-2006

- **Reading Across Curriculum**
  DCPS Professional Development Institute, USA Coordinator: Anne M. Holbrook

- **Architecture 201: Bringing Architecture to the Classroom**
  Washington Architectural Foundation Coordinator: Paula Sanderlin, Director of Art

2005

- **Standards Training**
  DCPS Staff Development, USA

- **Training for the teacher exchange program**
  Bahçeşehir University

2004

- **Total Quality Management & Computers and Internet Use**
  Ministry of Education in Turkey

2003

- **Expanding Horizons through Technology International Workshop**
  Centre for European Union Education and Youth Programs / National Agency

HONOURS/ AWARDS

2010

- **Educational Research Awards- Jury Special Award**
  "The nature of pre-service science teachers' argumentation in inquiry-oriented laboratory context" Ministry of Education-EARGED & SEBIT

2009

- **METU Thesis of the Year**
  "The nature of pre-service science teachers' argumentation in inquiry-oriented laboratory context" Master's Thesis

- **ESERA (European Educational Research Association) Travel Award**
  To study with Prof. Dr. Sibel Erduran, Bristol University

2008

- **Best of the Fifty Science Projects in Science: Project Advisor**
  "Measuring the amount of sugar by a laser system" With Kâtip Çelebi Elementary School Students Ministry of Education in Turkey

2003

- **Certificate of Appreciation**
  For contributions to "Expanding Horizons through Technology" By Rosalind Morton, Comenius Program Coordination

- **High Honour Student**
  Middle East Technical University By Prof. Dr. Ural AKBULUT, METU Rector

OTHER ACADEMIC ACTIVITIES

Reviewer International Journal of Science Education
Science & Education

Editor Assistant International Journal of Biology Education
Science Education International

Editor Assistant Kırşehir Eğitim Fakültesi Dergisi, 11(4), 2010
(Special Issue)

PUBLICATIONS

2014

Ozdem, Y., Dal, B., Ozturk, N., Sonmez, D., & Alper, U. (2014). What is that thing called climate change? An investigation into the understanding of climate change by seventh-grade students. International Research in Geographical and Environmental Education, online first.

Mehmetlioglu, D. & **Ozdem, Y.** (2014). Connectivity Theory at work: The referrals between science and mathematics in a science unit. *International Journal of Education in Mathematics, Science and Technology, 2*(1), 36-48.

2013

Huyuguzel Cavas, P., **Ozdem, Y.**, Cavas, B., Cakiroglu, J., & Ertepinar, H. (2013). Turkish pre-service elementary science teachers' scientific literacy level and attitudes toward science. *Science Education International*, 24(4), 383-401.

Dal, B., **Özdem, Y.**, Öztürk, N., & Alper, U. (2013). Building capacity for public understanding of science: a report on the role of science centers. *Bilge Strateji Dergisi, 5*(8), 57-67.

Ozdem, Y., Ertepinar, H., Cakiroglu, J., & Erduran, S. (2013). The nature of pre-service science teachers' argumentation in inquiry-oriented laboratory context. *International Journal of Science Education, 35*(15), 2559-2586.

2012

Cavas, B., Cavas, P., **Ozdem, Y.**, Rannikmae, M., & Ertepinar, H. (2012). Research trends in science education from the perspective of Journal of Baltic Science Education: A content analysis from 2002 to 2011. Journal of Baltic Science Education, 11(1), 94-102.

Cavas, B., **Özdem, Y.**, Cavas, P., Holbrook, J. (2012) "The use of Robotics in Science Education: Can Traffic Accidents be Eliminated by Robots?" ICASE International Teacher Seminar. Seminar Book, 65-73, 8-15 December 2012, Bangkok, Thailand.

Özdem, Y., Çavaş, B. (2012) "PROFILES Continuous Professional Development Workshops in Turkey" Inquiry Based Science Education in Europe: Reflections from the PROFILES Project. Book of invited presenters, 163-165, 24-26 September 2012, Berlin, Germany.

Cavas, B., **Özdem, Y.**, Cavas, P., Holbrook, J. (2012) "The use of Robotics in Science Education" Inquiry Based Science Education in Europe: Reflections from the PROFILES Project. Book of invited presenters, 192-195, 24-26 September 2012, Berlin, Germany.

2010

Özdem, Y., Demirdöğen, B., Yeşiloğlu, S. N., & Kurt, M. (2010). Farklı branşlardaki alan öğretmenlerinin sosyal yapılandırıcı yaklaşımla bilim anlayışlarının geliştirilmesi. *Kırşehir Eğitim Fakültesi Dergisi, 11*(4), 263-292.

Ozdem, Y., Cavas, P., Cavas, B., Cakiroglu, J. ve Ertepınar, H. (2010). An investigation of elementary students' scientific literacy levels. *Journal of Baltic Science Education, 9*(1), 6-19.

CONFERENCE PARTICIPATION

2014

Ozdem, Y. & Cakiroglu, J. "Fen Bilimlerinde Argümantasyon Öğrenimi ve Öğretimi Üzerine Eğitim Tasarımı Arastırması" (An educational design research on the teaching and learning argumentation in science education) (September, 2014), 1142. **(Presentation)**

2013

Cavas, B., **Ozdem, Y**., Alper, U., & Yilmaz, B. "FuLL-Science" IOSTE Eurasian Regional symposium & Brokage event Horizon 2020 (November, 2013), 58. **(Presentation/Poster)**

Cavas, B., **Ozdem, Y**., Cavas, P., Holbrook, J., Bulut, C., & Akpullukcu, S. "The effects of PROFILES modules on student motivation." IOSTE Eurasian Regional symposium & Brokage event Horizon 2020 (30 October- 01 November, 2013), 23. **(Presentation)**

Ozdem, Y. "Motivated for Science Education: Experiences in European Union Projects." Invited presentation in Bristol University, Centre for Interdisciplinary Studies in Science Education. Bristol (May, 2013) **(Invited Presenter)**

2012

Metin, D., Çakıroğlu, J., Tekkaya, C., Bilican, K., & **Özdem, Y.** "Fen Bilgisi Öğretmenliği Öğrencilerinin Bilimsel Bilgiye Bakış Açısı" Uygulamalı Eğitim Kongresi, Ankara (September, 2012). **(Poster)**

Erar, H., Alper, U., & **Özdem, Y.** "Where science diffuse into children's life: An Introduction of a Science Entertainment Centre and Facilities for Schools" 1.Uluslararası Bilim Merkezleri & Sürdürülebilir Kalkınma Eğitimi sempozyumu, İstanbul (June, 2012) **(Presentation)**

Erar, H., Alper, U., & **Özdem, Y.** "Sustainable science for children: facilities for primary school children utilising waste materials" 1. Uluslararası Bilim Merkezleri & Sürdürülebilir Kalkınma Eğitimi sempozyumu, İstanbul (June, 2012) **(Presentation)**

Çavaş, B., Holbrook, J., **Özdem, Y.**, Çavaş, P. "Networking among Science and Technology Teachers: Experiences from the PROFILES Project in Turkey to reduce heterogeneity in inquiry based science teaching and learning" 21st Symposium on Chemical and Science Education. 17-19 May 2012, Dortmund, Germany (2012). **(Presentation)**

Çavaş, B., **Özdem, Y.**, Çavaş, P., Kesercioğlu, T. "PROFILES: Bilim Yoluyla Sorgulamaya Dayalı Öğrenme ve Eğitim Üzerine Mesleki Yansıma Odaklı Bir Program" X.Fen ve Matematik Eğitimi Kongresi, Bildiriler Kitabı, 672-673, Nigde (2012). **(Presentation)**

Çavaş, B., **Özdem, Y.** "Fen ve Teknoloji Öğretmenlerinin Çevrimiçi Öğrenme Tasarımı, Becerilerinin Geliştirilmesine Yönelik Hizmet İçi Eğitim Projesi: LD Skills" X.Fen ve Matematik Eğitimi Kongresi, Bildiriler Kitabı, 17, Nigde (2012). **(Presentation)**

Erar, H., Alper, U., & **Özdem, Y.** "Eğlenceli Bilim: Bilim Merkezlerinin İlköğretim Öğrencilerinin Bilim Algıları ve Bilimsel Süreç Becerilerine Etkisi". X.Fen ve Matematik Eğitimi Kongresi, Bildiriler Kitabı, 98, Nigde (2012). **(Presentation)**
http://kongre.nigde.edu.tr/xufbmek/dosyalar/tam_metin/pdf/2531-31_05_2012-20_35_29.pdf

Sarıbaş, D., **Özdem, Y.,** & Ertepınar, H. "Laboratuar Ortamında Araştırılabilen Soru Oluşturma" X.Fen ve Matematik Eğitimi Kongresi, Bildiriler Kitabı, 712, Nigde (2012). **(Poster)**

Bilican, K., & **Özdem, Y.** "Informed experience to improve instructional practice on NOS and argumentation: A case study". International Conference on Interdisciplinary Research in Education, North Cyprus (May, 2012). **(Presentation)**

Çavaş, B., **Özdem, Y.**, Çavaş, P., Kesercioğlu, T. "What do stakeholders think about science education in Turkey? An example from PROFILES project" International Conference on Interdisciplinary Research in Education, North Cyprus (May, 2012). **(Presentation)**

Özdem, Y. "Fen Bilgisi Öğretmenlerinin Argümantasyona Yönelik Öğrenme Tasarımları Oluşturma Becerilerini ve Argümantasyon ve Öğrenme Tasarımlarına Yönelik Algılarını Araştırma ve Geliştirme" ODTÜ Sosyal Bilimler Enstitüsü 1. Sosyal Bilimler Doktora Öğrencileri Çalıştayı, Ankara (May, 2012) **(Presentation)**

Erduran, S., **Ozdem, Y.**, & Park, J.Y. "Research on argumentation in science education: A content analysis of key journals" AERA annual Conference, Vancouver, Canada (April 13-17, 2012) **(Presentation)**

2011

Çavaş, B., Kocagül, M., & **Ozdem, Y.** (2011, October). "Why a signal sound is heard when new generation cars are parking". European Distance Education Network (EDEN) Conference, Greece, 254-258. **(Presentation)**

Mehmetlioğlu, D., & **Ozdem, Y.** (2011, September 5-9). "A case study of a science unit to make connections between elementary science and mathematics". European Science Education Research Association (ESERA), Lyon, France. **(Presentation)**

Ozdem, Y., Erduran, S., & Park, J. Y. (2011, September 5-9). "The development of an argumentation theory in science education". European Science Education Research Association (ESERA), Lyon, France. **(Presentation)**

Park, J. Y., Erduran, S., & **Ozdem, Y.** (2011, September 5-9). "Model of argumentation in science education research". European Science Education Research Association (ESERA), Lyon, France. **(Sözlü Bildiri)**

Erduran, S., **Ozdem, Y.,** & Park, J. Y. (2011, April 3-6). "Trends in research on argumentation: Content analysis of science education journals". NARST Annual International Conference, Orlando, Florida, USA. **(Presentation)**

2010

Taşdelen, U., Köseoğlu, F., **Ozdem, Y**., & Demirdöğen, B. (2010, November). "Interactive evaluation of nature of science: a taboo-like game as a final semester activity". ICERI 2010 International Conference of Education, Research and Innovation, Madrid **(Presentation)**

Tümay, H., **Ozdem, Y.,** Bilican, K., & Küçüker, S. (2010). "Öğretmen ve öğretmen adayları için bilimin doğası öğretimi mesleki gelişim paketi –etkinlik örnekleri II". 9. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, İzmir, Türkiye, 23-25 September **(Presentation)**

Taşdelen, U., Üstün, U., Küçüker, S., & **Ozdem, Y.** (2010). "Öğretmen ve öğretmen adayları için bilimin doğası öğretimi mesleki gelişim paketi - proje tabanlı öğrenme etkinlikleri". 9. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, İzmir, Türkiye, 23-25 September. **(Presentation)**

Ozdem, Y., Ertepınar, H., & Cakıroglu, J. (2010). "Argümantasyona dayalı araştırma temelli laboratuar uygulamalarında öğretmen adaylarının argüman yapıları". 9. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, İzmir, Türkiye, 23-25 September **(Presentation)**

Ozdem, Y., Ertepınar, H. & Cakiroglu, J. (2010). "Understanding the nature of pre-service science teachers' argumentation during laboratory work". National Association for Research in Science Teaching (NARST) 2010 Annual International Conference, Philadelphia, USA, 20-24 March. **(Presentation)**

Bilican, K., **Ozdem, Y.** & Tekkaya, C. (2010). "A qualitative study of pre-service science teachers' understanding of nature of science and their approaches to science teaching". XIV. International Organization for Science and Technology Education Symposium (IOSTE), Slovenia, 13-18 June. **(Presentation)**

Koseoglu, F., Demirdogen, B., **Ozdem, Y.** & Tasdelen, U. (2010). "Interactive evaluation of nature of science: a taboo-like game as a final semester activity". XIV. International Organization for Science and Technology Education Symposium (IOSTE), Slovenia, 13-18 June. **(Presentation)**

2009

Ozdem, Y., Ertepınar, H., Cakıroglu, J. & Topcu, M. S. (2009). "The nature of pre-service science teachers' argumentation in laboratory work". European Conference on Educational Research Pre-conference, Vienna, 25 - 26 September **(Presentation)**

Cavas, P., **Ozdem, Y.**, Cavas, B. & Ertepınar, H. (2009). "The Turkish Science and Science Education Students' Scientific Literacy Level". European Conference on Educational Research Pre-conference, Vienna, 25 - 26 September **(Presentation)**

Ozdem, Y., Tümay, H, & Köseoğlu, F. (2009). “Effects of social and cognitive strategies on prospective teachers’ scientific argumentation”. European Science Education Research Association Conference, İstanbul, Türkiye, 31 August-4 September **(Presentation)**

Tekkaya, C., Bilican, K., & **Ozdem, Y.** (2009). “A case study on pre-service teachers’ understanding of NOS and related pedagogical content knowledge”. European Science Education Research Association Conference, İstanbul, Türkiye, 31 August-4 September **(Presentation)**

Adıbelli, E. & **Ozdem, Y.** (2009). “The analysis of new Turkish science and technology curriculum in terms of STS objectives”. The Sixteenth International Conference on Learning, Barcelona, 1-4 July. **(Presentation)**

Cavas, P., **Ozdem, Y.**, Cavas, B. v& Ertepınar, H. (2009). “The Examination of the Turkish University Students' Scientific Literacy Level”. International Popularity and Relevance of Science Education for Science Literacy Conference, Berlin, 1-4 March. **(Poster)**

2008

Bilican, K., **Ozdem, Y.** & Tekkaya, C. (2008). “Fen okuryazarlığı boyutlarının ders planlarına dâhil edilmesinin pekiştirilmesi üzerine ilköğretim fen bilgisi öğretmen adayları ile bir uygulama”. 8. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, Bolu, Türkiye, 27-29 August. **(Presentation)**

Ozdem, Y., Ertepınar, H. & Cakiroglu, J. (2008). “Investigation of the basic scientific literacy at elementary level”. Proceedings of XIII. IOSTE Symposium, Kuşadası, Türkiye, 1333-1338. **(Poster)**

H. TURKISH SUMMARY

FEN BİLİMLERİ ÖĞRETMENLERİNİN, FEN EĞİTİMİNDE ARGÜMANTASYONA İLİŞKİN KURAM VE PEDAGOJİLERİ: BİR YÜKSEKÖĞRETİM DERSİNİN EĞİTİM TASARIM ARAŞTIRMASI İLE TASARIMI, UYGULAMASI VE DEĞERLENDİRİLMESİ

1. Giriş: Fen Eğitiminde Argümantasyon

Argümantasyon, bilimsel iddiaların, deneysel ya da kuramsal deliller ile desteklendiği ve değerlendirildiği bilimsel tartışma ve sosyal etkileşim sürecidir (Jimenéz-Aleixandre ve Erduran, 2008). Bu süreçte, öğrencilerin bilimsel/ sosyo-bilimsel içerikli konularda argümanlar oluşturmaları, argümanları ve gerekçelerini sorgulamaları, farklı bakış açılarıyla oluşturulan argümanları değerlendirerek bilimsel anlamda nitelikli açıklamalara ulaşmaları beklenir (Driver, Newton ve Osborne, 2000).

Araştırmalar, fen bilimleri eğitiminde argümantasyonun, öğrencilerin bilimsel okuryazarlık becerisi kazanmalarına (Aslan, 2014; Norris ve Phillips, 2003; Tonus, 2012; Tümay, 2008), bilimsel içeriği öğrenmelerine (Bell ve Linn, 2000; Zohar ve Nemet, 2002), üst düzey akıl yürütme, eleştirel düşünme ve karar verme becerileri geliştirmelerine (Lawson, 2003; Yeşiloğlu, 2007; Zhou, 2010), bilimsel bilginin nasıl yapılandırıldığını ve değerlendirildiğini anlamalarına (Dawson ve Venville, 2009; Jiménez-Aleixandre ve Erduran, 2008) ve sosyal becerilerini geliştirmelerine (Kuhn ve Udell, 2003) destek olduğunu göstermektedir.

Ülkemizde ortaokul düzeyinde uygulanmakta olan fen ve teknoloji öğretim programında ve 2012-2013 eğitim öğretim yılında aşamalı olarak uygulanmasına karar verilen fen bilimleri dersi öğretim programında, fen eğitiminin vizyon ve amaçlarını gerçekleştirmek üzere, açık ya da örtülü ifadelerle argümantasyona yer verilmektedir (MEB, 2006; 2013).

1.1. Problem Durumu

Argümantasyon uygulamalarının olumlu yönlerinin sıklıkla ortaya konulmasına ve öğretim programlarında argümantasyona yer verilmesine rağmen, fen derslerinde öğrencilere olayları ve deneyleri yorumlama ya da sosyo-bilimsel konularda fikirlerini tartışma fırsatı çok az verilmektedir (Driver, Newton, ve Osborne, 2000; Jiménez-Aleixandre ve Erduran, 2008) Bu doğaldır çünkü bir çok öğretmen için argümantasyon, bilimsel tartışma tekniklerini bilmeyi ve delile dayalı argümantasyon aktivitelerini yürütmede deneyimli olmayı gerektirir (Zembal-Saul, 2009; Zohar, 2008). Ancak yapılan araştırmalar, öğretmenlerin bir çoğunun ya argümantasyon yaklaşımına aşina olmadıklarını (Jiménez-Aleixandre, 2008) ya da argümantasyon yaklaşımını uygulamanın kendi pedagojilerinde ciddi bir anlayış değişikliği gerektirdiği için uygulamada rahat hissetmediklerini ortaya koymuştur (Simon, Erduran, ve Osborne, 2006; Zohar, 2004; Zohar, 2008).

1.2. Araştırmanın amacı:

Yukarıda belirtilen problem durumuna yönelik olarak, bu araştırmada, öğretmenlerin argümantasyon yaklaşımını anlamaları, benimsemeleri, deneyim kazanmaları amacıyla bir öğretmen eğitimi gerçekleştirilmesi amaçlanmıştır. Bu amaç doğrultusunda, Eğitim Tasarım Araştırması kullanılarak bir yüksek lisans dersi programı geliştirilmiştir. Ders tasarımı ile (1) öğretmenlerin argümantasyon öğretimi ve öğrenimi üzerine kuramsal bilgilerinin ve uygulama deneyimlerinin kazandırılması ve geliştirilmesi, (2) bu süreçte öğretmenlerin argümantasyona dayalı fen öğretimi yapma yönünde gelişimlerinin izlenmesi ve (3) argümantasyona ilişkin kuramsal bilgi sahibi öğretmenlerin fen bilimleri derslerinde argümantasyon uygulamaları gerçekleştirirken kullandıkları öğretim stratejilerinin araştırılması amaçlanmıştır.

Bu amaca yönelik olarak araştırılan sorular şu şekildedir:

1. Fen öğretimi ve öğreniminde argümantasyona ilişkin kuramsal ve pedagojik bilgi kazandırmayı amaçlayan bir yükseköğretim dersi, fen bilimleri öğretmenlerinin argümantasyona ilişkin bilgilerine nasıl katkıda bulunmaktadır?
    a. Fen öğretimi ve öğreniminde argümantasyona ilişkin kuramsal ve pedagojik bilgi kazandırmayı amaçlayan bir yükseköğretim dersinin içeriği nasıl olmalıdır?
    b. Fen öğretimi ve öğreniminde argümantasyona ilişkin kuramsal ve pedagojik bilgi kazandırmayı amaçlayan yükseköğretim dersini alan fen bilimleri öğretmenlerinin ders süresince argümantasyona ilişkin anlayışları nasıl değişmektedir?
2. Fen bilimleri öğretmenlerinin, yükseköğretim dersi boyunca fen sınıflarında yaptıkları argümantasyona dayalı uygulamalarda ve ders planlarında kullandıkları öğretim stratejileri nelerdir?

    a. Argümantasyona dayalı fen sınıfı uygulamalarına ilişkin öğretmenlerin yaptıkları tekrarlanan yansıtıcı eleştiriler öğretmenlerin argümantasyona yönelik öğretim stratejilerini kullanmalarını pekiştirir mi?
3. Fen öğretimi ve öğreniminde argümantasyona ilişkin kuramsal ve pedagojik bilgi kazandırmayı amaçlayan yükseköğretim dersi sürecinde argümantasyona yönelik kuram ve uygulama arasındaki farklılıklar nasıl ortaya konulmaktadır?
    a. Fen öğretimi ve öğreniminde argümantasyon yüksek lisans dersini alan öğretmenlerin argümantasyona dayalı fen sınıfı uygulamalarında kuramsal bilgileri ve uygulamaları arasındaki farklılıklar nasıl ortaya konulmaktadır?
    b. Fen öğretimi ve öğreniminde argümantasyona ilişkin kuramsal ve pedagojik bilgi kazandırmayı amaçlayan yükseköğretim dersini alan fen bilimleri öğretmenlerinin ders süresince argümantasyona ilişkin pedagoji anlayışları nasıl değişmektedir?
4. Fen öğretimi ve öğreniminde argümantasyona ilişkin kuramsal ve pedagojik bilgi kazandırmayı amaçlayan yükseköğretim dersine ilişkin bir araştırmacı ve bir eğitmen olarak deneyimlerim nelerdir?
5. Fen öğretimi ve öğreniminde argümantasyona ilişkin kuramsal ve pedagojik bilgi kazandırmayı amaçlayan yükseköğretim dersi sürecinde bir eğitmen olarak benim deneyimlerimde argümantasyona yönelik kuram ve uygulama arasındaki farklılıklar nasıl ortaya konulmaktadır?

Bu çalışmaya yukarda verilen araştırma sorularını cevaplamak amacıyla argümantasyona yönelik başarılı öğretmen mesleki eğitim programlarını temel alan ve yinelenerek geliştirilen bir yüksek lisans dersi tasarladım. Bu dersi tasarlarken amacım fen bilimleri öğretmenlerine, öğrencilerinin fen bilimleri derslerinde kendi kendilerine argümantasyon sürecini başlatabilecekleri ve dahil olabilecekleri bir öğretim yöntemini sınıflarına taşıyabilme konusunda yeterlilik kazandırmaktı. Böyle bir dersin tasarlanmasında öğrenme teorilerinin eğitim tasarımını şekillendirebileceği ve aynı zamanda oluşturulan eğitim tasarımının ortaya koyduğu bulguların bu öğrenme teorilerine katkıda bulunabileceği bir yöntem izlenmesi gerekmektedir (Kelly, Lesh, & Baek, 2008; Majgaard, Misfeldt, & Nielsen, 2011). Böyle bir yöntem bu çalışmada Eğitim Tasarım Araştırması (ETA) olarak belirlendi. Bu araştırma yöntemi ile öğretmenlerin argümantasyona yönelik kuramsal ve pedagojik bilgilerini geliştirmek için fen bilgisi eğitiminde argümantasyona ilişkin gelişmekte olan teoriden yararlandım ve sonuçta yine bu teoriye katkıda bulunan bir çalışma yapmayı hedefledim.

1.3. Araştırmanın önemi:

Bu çalışmada geliştirilen öğretim programı hem alan yazın hem de öğretmen eğitimi açısından önemlidir. Teorik olarak, bu çalışma öğretmenlerin argümantasyon konusunda pedagojilerinin gelişimini betimlemekte ve ETA'nın öğretmenlerin argümantasyon teorisi ve uygulamalarını geliştirmeye nasıl katkıda bulunduğunu açıklamaktadır. Uygulama yönünden ise, ETA ile geliştirilen tasarım, hem dayandığı kuramsal temeller, hem de uygulama açısından yinelenerek değerlendirildiği için etkili bir ürün olarak ortaya konulmaktadır.

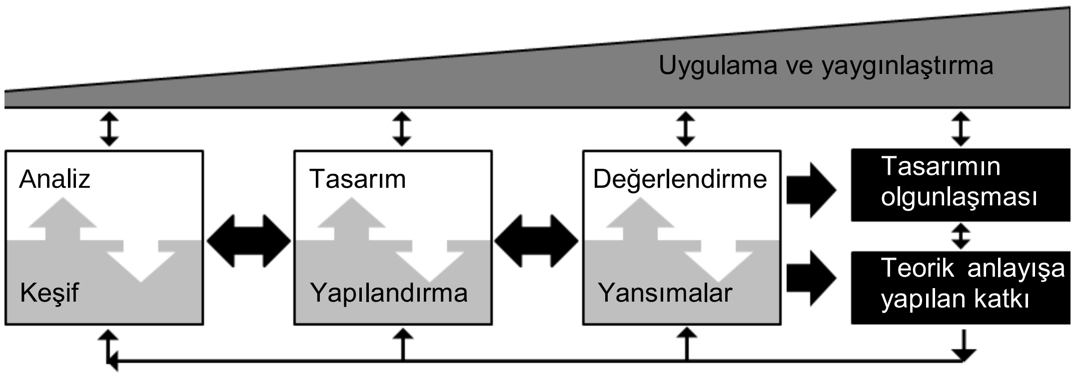
2. Yöntem: Eğitim Tasarım Araştırması

ETA eğitim alanında uygulamada karşılaşılan güçlüklere çözümler geliştirmek amacıyla yapılan, kuramsal araştırmalardan hem beslenen hem kuramın geliştirilmesine katkı sağlayan, döngüsel içerikli bir araştırma desenidir (McKenney ve Reeves, 2012; Kelly, Lesh, ve Baek, 2008; Majgaard, Misfeldt, ve Nielsen, 2011).

Bu çalışmada ETA'nın kullanılmasının temel olarak iki sebebi vardır: Birincisi, basılı eğitim araştırmalarının çokluğu ve eğitim alanındaki gelişmeler düşünüldüğünde bu ikisi arasındaki ilişkinin oldukça zayıf olmasıdır (Reeves, McKenney, & Herrington, 2011). Bir başka deyişle, eğitim alanında yapılan oldukça kaliteli araştırmalar olmasına rağmen bu araştırmaların uygulamada eğitime yansımalarının oldukça yetersiz kalmasıdır. Bu soruna yönelik olarak Reeves ve diğerleri (2011) ETA'nın araştırma ve uygulama arasındaki ayrılıkları ortadan kaldırmaya yönelik etkili bir araştırma yöntemi olduğunu belirtmişlerdir.

Diğer gerekçe ise ETA'nın dönüşümsel (transformational) öğretmen öğrenmesi modelini destekleyen bir yapıya sahip olmasıdır. Dönüşümsel öğretmen öğrenmesi, araştırmaların kuramsal temellerinin öğretmenlere sunulduğu ve öğretmenlerden bu fikirleri nasıl öğretim ortamlarına taşıyabileceklerini düşünmelerinin istendiği bir öğretmen eğitim yaklaşımıdır (Kennedy, 2005). ETA'nın teori ile şekillenen, gerçek ortamda uygulama ile test edilen ve işbirlikli çalışmaya yönelik yapısı nedeniyle dönüşümsel öğretmen öğrenmesinin gerekliliklerini karşıladığı düşünülmektedir.

Bu çalışmada farklı modeller göz önüne alınarak McKenney ve Reeves (2012) tarafından geliştirilen kapsamlı ETA modeli uygulanmıştır. Bu model üç aşama ile gösterilebilir ancak bu üç aşamanın birbirinden ayrı ve sırasıyla takip edilecek üç aşama olmadığı, aksine bu üç aşamanın birbiriyle içiçe geçmiş olduğu vurgulanmalıdır. Aşamalardan ilki analiz ve keşif aşaması, ikincisi tasarım ve yapılandırma, ve üçüncüsü değerlendirme ve yansımalar aşamasıdır (Şekil 1). Bu çalışmada tüm süreç iki dönem (13 hafta x 2) boyunca sürmüştür.



Şekil 1. Kapsamlı Eğitim Tasarımı Araştırması Modeli

2.1. Katılımcılar

Çalışmaya 1 yüksek lisans öğrencisi fen bilgisi öğretmeni, 2 doktora öğrencisi kimya öğretmeni, 1 doktora öğrencisi, 1 doktora öğrencisi araştırma görevlisi, 2 yüksek lisans öğrencisi araştırma görevlisi seçmeli bir ders olarak açılan “Fen Öğretimi ve Öğreniminde Argümantasyon” başlıklı derse kendi istekleri ile kayıt yaptırarak katılmışlardır. Katılımcılara kayıt öncesinde ders ve çalışma hakkında bilgilendirme yapılmış ve çalışmaya katılımları için onayları alınmıştır.

2.2. Veri kaynakları

Çalışmaya veri oluşturmak üzere geliştirilen eğitim tasarımın uygulamaları ve değerlendirilmesi aşamalarında tasarım uygulanırken (1) her hafta ses kaydı alındı; (2) katılımcıların tasarımın içeriği ve uygulanması ile ilgili haftalık değerlendirmeleri ve (3) üç farklı zamanda argümantasyon ile ilgili yazılı görüşleri alındı; (4) uygulama öncesi ve sonrası katılımcılar ile yarı-yapılandırılmış görüşmeler yapıldı; (5) katılımcıların argümantasyona dayalı olarak geliştirdikleri fen bilimleri derslerinin ders planları, (6) uygulama esnasındaki video kayıtları, (7) öğrencileri ile gerçekleştirdikleri etkinliklerin yazılı materyalleri ve (8) uygulamalarına ilişkin öğretmenlerin yansıtıcı eleştirileri alındı; (9) araştırmacı olarak benim tez danışmanım, tez izleme komitesi ve uygulama esnasında sınıfta diğer katılımcılar gibi sürece katılan bir gözlemci ile tasarımın uygulanması sürecinde yaptığım toplantı kayıtları alındı.

2.3. Verilerin Değerlendirilmesi

Bu çalışmada veriler amaca yönelik olarak üç farklı analiz yöntemi ile değerlendirilmiştir.

1. *Fen dersi sınıf uygulamalarının yorumlayıcı içerik analizi*; Bu çalışmada katılımcı öğretmenlerden derste edindikleri teorik bilgileri yansıtan dersler planlamaları ve bunların ikisini gerçek sınıf ortamında denemeleri istendi. Öğretmenlerin gerçek sınıf ortamında uyguladıkları argümantasyona dayalı dersler video kayıt yöntemiyle öğretmenlerin kendileri tarafından kaydedildi. Öğretmenlerin ders kayıtları yazıya aktarıldı ve yorumlayıcı içerik analizi ile bu veriler değerlendirildi. Analizde öğretmenlerin hangi diyaloglarının argümantasyonu başlattığı ya da desteklediği ortaya konuldu.
2. *Görüşmeler ve yansıtıcı eleştirilerin yorumlayıcı olgubilimsel analizi*; Çalışmaya katılan öğretmenlerle Fen Öğretimi ve Öğreniminde Argümantasyon dersi öncesinde ve ders sonunda yarı yapılandırılmış görüşmeler gerçekleştirildi. Ayrıca öğretmenlerden yazılı ve sözlü olarak hem derste kendi öğrenmelerine ilişkin hem de kendi argümantasyon uygulamalarına ilişkin yansıtıcı eleştiri yapmaları istendi. Bu veri kaynaklarından oluşturulan veriler yorumlayıcı olgubilimsel analiz ile değerlendirildi. Analizde öğretmenlerin süreç, kendi öğrenmeleri ve sınıf uygulamalarına yönelik olarak değerlendirmeleri ve deneyimleri kodlandı.
3. *Kişisel anlatı analizi*; Bu çalışmada bir araştırmacı ve aynı zamanda eğitici olarak benim argümantasyon ile ilişkili ön bilgilerim, uygulamalarım ve deneyimlerim otoetnografi yaklaşımıyla ele alındı. Veri kaynakları olarak daha önce yapmış olduğum ulusal ve uluslararası argümantasyon ve öğretmen eğitimi ile ilgili çalışmalarım kişisel anlatı analizi ile değerlendirildi.

2.4. Çalışmanın İnandırıcılığı

Nicel çalışmalarda çalışmanın kalitesi geçerlik ve güvenirlik kavramları ile değerlendirilmektedir. Bu kavramlar gerçekliğin insandan bağımsız olarak var olduğunu ileri süren, gerçekliğin genellebilir olduğunu savunan pozitivist paradigmanın varsayımları ile örtüşmektedir. Ancak gerçekliği karmaşık bulan, insana hatta kişiye, duruma, ortama bağlı olduğunu ve dolayısıyla genellemenin mümkün olmadığını savunan yorumlamacı paradigmanın gereği olarak, inandırıcılık (trustworthiness) kavramı ortaya çıkmıştır (Yıldırım, 2010). Bu çalışmada inandırıcılık şu yollarla sağlandı:

1. *Düşünümsellik*: Düşünümsellik, yorumlayıcı paradigmanın en önemli bileşenlerindendir çünkü bu yolla araştırmacı içinde konumlandığı ve bir parçası olduğu araştırmadaki kendi durumunu idrak eder ve bunu açıklar. Düşünümsellik, araştırmada araştırmacının varlığının bir dış etkenden ziyade araştırmanın her aşamasına etki eden bir bileşen olduğunu gösterir. Araştırmacı düşünümsellik yoluyla araştırmadaki kendi rolünü ortaya koyar ve bu durum inandırıcılığı önemli ölçüde artırır (Schwartz-Shea & Yanow, 2012). Bu çalışmada, ben de araştırmacı ve eğitici olarak bu araştırmadaki rolüm, düşüncelerim, yorumlarım ve araştırma durumunda etkili olabilecek benimle ilgili her türlü ayrıntıya araştırma içinde yer vererek ve bu durumun araştırma üzerindeki etkisini idrak ederek düşünümselliğe başvurdum.
2. *Katılımcı kontrolü*: Bu çalışmada katılımcılar ile gerçekleştirilen ön ve son görüşmeler, öğretmenlerin sınıf içi uygulamalarının bir kısmı ve derse ilişkin yaptığım bazı kodlamalar İngilizce ve Türkçe olarak yazıya aktarıldı ve kontrol için katılımcılara gönderildi. Katılımcılar bu dokümanları inceleyerek yorum, görüş ve önerilerini ilettiler ve bu doğrultuda gerekli değişiklikler yapılarak kodlama işlemine geçilmeden önce katılımcı kontrolü sağlandı.
3. *Ayrıntılı betimleme*: Bu çalışmada kuramsal dayanak ve araştırmanın bütün aşamaları diğer araştırmacılaın çalışmanın verilerini yorumlayabilmesi ve gerektiğinde benzer bir süreci takip edebilmeleri için ayrıntılı ve açık olarak anlatıldı. Ancak, diğer araştırmacıların verileri farklı deneyimlere sahip olduğu ve dolayısıyla verileri farklı şekillerde yorumlayabileceği gerçeği yorumlayıcı araştırma açısından olağan görülmektedir (Gravemeijer & Cobb, 2006; Schwartz-Shea & Yanow, 2012).

Bunlara ek olarak, Creswell (2007) tarafından önerilen uzun süreli etkileşim (toplam 26 hafta) ve farklı veri kaynaklarının üçlemesi yöntemleri de inandırıcılığı artırmaktadır.

3. Yükseköğretim Dersinin Geliştirilmesi: Fen Eğitimi ve Öğretiminde Argümantasyon

Bu bölüm çalışmanın somut ürünü olarak bir eğitim tasarımının geliştirilmesini ve olgunlaştırılmasını anlatmaktadır. ETA desenine uygun olarak tasarımın geliştirilmesi (1) analiz ve keşif, (2) tasarım ve yapılandırma, ve (3) değerlendirme ve yansımalar aşamalarını takip etmiştir.

3.1. Analiz ve Keşif

Analizle ilişkili olan amaç problem durumunun tanımlanmasıdır. Araştırmacı bu amaçla ortam ve ihtiyaç analizi ve alan yazın taraması yapabilir. Problemin durumunun doğru tanımlanması için ayrıca ilgili kişilerin- öğretmenler, eğitim araştırmacıları, eğitim yöneticileri, öğrenciler vb.- görüşlerinin alınması ve problem durumunun nedenlerinin analizi de bu aşamada araştırmacı tarafından dikkate alınmalıdır.

Bu çalışmada analiz alan yazın taraması ve ön görüşmeler yoluyla gerçekleştirilmiştir. Ön görüşmelerde öğretmenlere argümantasyon ya da herhangi başka bir müzakere yönteminin fen derslerinde kullanılmasına yönelik görüşleri ve yaşadıkları sorunlar sorulmuş ve çalışma öncesi argümantasyon yöntemine aşina olup olmadıkları araştırılmıştır.

Keşif ile ilgili olarak amaç problem durumunun derinlemesine irdelenmesi ve problemin çözümüne yönelik araştırma yapılmasıdır. Araştırmacı, problemin çözümüne yönelik daha önce yapılan girişimleri problem durumuyla doğrudan ilişkili saha araştırması, ilgili uzmanlarla görüşmeler ve ilgili toplantılara katılarak iletişim ağı oluşturmak yollarıyla ortaya koyabilir (McKenney & Reeves, 2012).

Bu çalışmada çözüme yönelik araştırma için konferanslara katıldım, uzmanlarla görüştüm ya da e-posta ile iletişim kurdum ve tez izleme komitesi ile yılda iki defa toplantılar gerçekleştirdim.

3.2. Tasarım ve Yapılandırma

Tasarım aşamasının amacı problem durumuna çözüm önerilerinin araştırılması ve düzenlenmesidir (McKenney & Reeves, 2012).

Bu amaçla, problem durumunun çözümüne yönelik bir eğitim tasarımı oluşturmak amacıyla daha önce araştırmacılar tarafından geliştirilmiş, uzun süreli ve başarılı örnekler alan yazın taranarak derlendi. Bu derlemede Erduran ve Yang (2009) tarafından yayınlanan *Minding Gaps in Argument* [Argümanda Boşluklara Dikkat Etmek], üç farklı grubun yürütücülüğünde (Erduran & Yan, 2011; Jiménez-Aleixandre, et al., 2011; Tiberghien, Vince, Coince, & Malkoun, 2011) yayınlanan *Science Teaching Advanced Methods* [İleri düzey Fen Öğretim Yöntemleri], Tümay (2008) tarafından doktora tezinin bir parçası olarak geliştirilen *Argümantasyon Odaklı Kimya Öğretimi* dersi, Erduran, Yee ve Ingram (2011) tarafından yayınlanan *The Assessment and Practical Inquiry in Scientific Argumentation* (APISA) [Bilimsel Argümantasyonda Ölçme ve Pratik Araştırma] kaynakları ve Sadler (2006) tarafından geliştirilen *Promoting discourse and argumentation in science teacher education* [Fen Bilimleri Öğretmen Eğitiminde Söylem ve Argümantasyonun Teşvik Edilmesi] dersi incelendi ve ortak özellikleri belirlendi. Bir çözüm ortaya konulması için fizibilite çalışması gerçekleştirildi. Bu özelliklerden ve içeriklerden yararlanılarak ilk prototip geliştirildi.

Yapılandırma aşamasının amacı çözüm oluşturabilecek ilk prototip eğitim tasarımını yapılandırmaktır. Bu prototip eğitim yazılımı, eğitim materyali ya da öğretim yöntemi gibi bir eğitim aracı olabilir (McKenney & Reeves, 2012).İlk prototip daha sonraki aşamalarda denenerek geliştirilir. Bu çalışmada ortaya konulan eğitim tasarımı bir yüksek lisans dersidir.

3.3. Değerlendirme ve Yansımalar

Bu aşamada geliştirilen eğitim tasarımı döngüsel bir süreçte denenerek etkililiği ile ilgili veriler oluşturularak değerlendirilir. Araştırmacı bu verilere dayanarak teorik anlayışa katkıda bulunmak ve eğitim tasarımını daha etkili hale getirmek için düşüncelerini ve deneyimlerini paylaşır.

Bu çalışmada iki temel araştırma sorusundan söz edilebilir: Biri eğitim tasarımına yönelik olan geliştirilen yüksek lisans dersinin öğretmenlerin fen öğretimi ve öğreniminde argümantasyon ile ilgili kuramsal ve pedagojik bilgilerini gelitirmede ne derece etkili olduğuyla ilgilidir. Diğeri ise öğretmenlerin fen bilimleri eğitiminde argümantasyona dayanan derslerinde kullandıkları öğretim stratejileri ile ilgilir. Bu nedenle, bu çalışmada hem eğitim tasarımına yönelik hem de öğretim stratejilerine yönelik iki değerlendirme vardır. Her değerlendirmeden sonra bu konulara yönelik yansıtıcı düşünme de gerçekleştirildi. Böylece hem fen eğitminde argümantasyon teorisine katkıda bulunmak hem de bu yönde öğretmenlere verilecek bir eğitime yönelik eğitim tasarımını olgunlaştırılması sağlandı.

3.4. Veri Kaynakları

1. *Ön Görüşme*: Ön görüşmeler katılımcı öğretmenlerin alan yazın ile ortaya koyulan problem durumunu aynı şekilde algılayıp algılamadıklarını öğrenmek amacıyla yapılmıştır. Ön görüşme dört bölümden oluşmaktadır: birinci bölümde öğretmenlerinin kendileri hakkında – akademik geçmiş, öğretmenlik deneyimi- bilgileri soruldu. İkinci bölümde öğretmenlerden maddenin tanecikli yapısıyla ilgili bir argüman oluşturmaları istendi. Üçüncü bölümde öğretmenlerin argümantasyonun fen eğitiminin bir parçası olması ile ilgili görüşleri soruldu. Son bölümde ise bir fen konusuna ilişkin öğrencilerin

kurduğu iki farklı argüman verilerek öğretmenlerden bu iki argümanı değerlendirmeleri istendi.

3.5. Bulgular

Öğretmenlerin argümantasyona ilişkin ön görüşleri; Genel olarak öğretmenlerden biri hariç- Mesut- ders öncesinde argümantasyon ile ilgili bir fikre sahip değillerdi. Bu nedenle ön görüşmede sorulara verdikleri cevaplar daha genel bir söylem çerçevesinde oldu. Öğretmenlerin argümantasyonun ya da diğer söylem türevlerine fen sınıflarında yer verilmesi ile ilgili görüşleri üç kategoride değerlendirildi: gereklilikler, zorluklar ve teknikler. Gereklilikler, uygun koşullar, rollerin doğru dağılımı ve etkili bir söylem için doğru içerik seçilmesi olarak kodlandı.

Öğretmenlerin argümantasyon ile ilgili bir fikri olmamasına rağmen Toulmin'in Argüman Yapısı analizine göre iki öğretmen ikinci düzeyde- bir veri, gerekçe ya da dayanak ile desteklenmiş bir iddia-, dört öğretmen dördüncü düzeyde- bir çürütücü ile desteklenmiş argüman- oluşturabildiler. Bu bulgu öğretmenlerin bir bilimsel iddianın nasıl olması gerektiğiyle ilgili bilgi sahibi olduklarını göstermektedir.

Tüm öğretmenler verilen öğrenci argümanlarını değerlendirirken bilimsel kavramların kullanılmasının iddiaların kalitesi açısından önemli olduğunu belirttiler. Mesut öğrenci iddialarını gösterdikleri gerekçeler bakımından değerlendiren tek öğretmendi. Mesut dışında diğer öğretmenler değerlendirme için bilimsel kavramların doğru kullanımından başka bir ölçüt gösteremediler.

Son olarak, ETA'nın aşamaları izlenerek oluşturulan ve uygulamaya konulan eğitim tasarımına ilişkin delile dayalı bulgular şu şekilde özetlenebilir:

1. Tasarım uygulaması tüm katılımcıların argümantasyon ile ilgili kuramsal bilgi ve anlayışlarının kazandırılmasına/ geliştirilmesine yardımcı oldu;
2. Tasarım uygulamasında katılımcıların tümünün argümantasyon alanında deneyim kazandıkları ancak deneyimlerin katılımcıların 5'i için kendi öğretmenlik yaptıkları sınıflarında gerçekleşmediğinden yetersiz kaldığı tespit edildi;
3. Geliştirilen tasarım tüm katılımcılarda argümantasyon öğrenimi ve öğretimi açısından üst düzey (meta-level) düşünmenin gerçekleşmesine katkıda bulundu.

3.6. Sonuçlar ve öneriler

Sonuç olarak ETA deseni ile geliştirilen, argümantasyon öğretimi ve öğrenimi üzerine yüksek lisans ders programı verilerle desteklenen etkili bir öğretmen eğitim programı olarak ortaya konulmaktadır. Katılımcıların yüksek öğrenim gören öğretmen eğitimi mezunları ve öğretmenler olduğu düşünüldüğünde tasarım argümantasyon konusunda üst-düzey bir öğretim içeriği ile oluşturulmuş ve bu niteliğini korumuştur. Bu öğretim içeriği ile katılımcılar argümantasyon konusunda teorik bilgiler edinmenin yanısıra bu bilgileri yaptıkları uygulamalar ile destekleme imkanı buldular. Bu yönüyle tasarım eğitim araştırmalarında sıklıkla bir sorun olarak gösterilen kuram ve uygulama arasındaki ayrılıkları ortadan kaldırmaktadır (Reeves, McKenney, & Herrington, 2011). Bu tasarım yüksek öğrenim görmeyen öğretmenler için uygulamada zorluklar içerebilir ancak bu çalışmayı şekillendiren ETA deseni bu amaçla geliştirilecek tasarımlar için bir örnek oluşturacaktır.

4. Fen Bilimleri Öğretmenlerinin Argümantasyona Dayalı Fen Derslerinde Kullandıkları Öğretim Stratejileri

Bu bölüm çalışmanın fen eğitiminde argümantasyon teorisine katkısını anlatmaktadır. Fen öğretimi ve öğreniminde argümantasyon üzerine yüksek öğrenimde ders gören öğretmenlerin fen sınıflarında yaptıkları argümantasyona dayalı uygulamalarda kullandıkları öğretim stratejileri bu çalışma ile ortaya konulmaktadır. Öğretmenlerden argümantasyon dersini alırken üç farklı zamanda argümantasyona dayalı fen dersi ders planı hazırlamaları ve bu ders planlarından ikisini gerçek fen sınıflarında uygulamaları istendi. Bu ders planları ve uygulamalar öğretmenlerin kullandıkları öğretim stratejilerini ortaya koymak üzere incelendi.

4.1. Veri Kaynakları

Çalışmanın bu bölümünde veri kaynakları olarak katılımcı öğretmenlerin gerçek fen sınıflarında yaptıkları argümantasyona dayalı fen dersi uygulamalarının öğretmenler tarafından kaydedilen video kayıtları, öğretmenlerin yaptıkları uygulamalarla ilgili olarak argümantasyon dersinde yaptıkları yansıtıcı eleştiriler, son görüşmeler, ders planları ve diğer yazılı dokümanlar, örneğin derste kullandıkları öğrenci çalışma kağıtları, kendi öz-yansıtma ödevleri, incelendi.

4.2. Bulgular

Bu bölümde bulgular iki araştırma sorusuna cevap vermek üzere ortaya konuldu: Birinci soru fen öğretimi ve öğreniminde argümantasyon yüksek lisans dersini alan öğretmenlerin ders süresince gerçek fen sınıflarında uyguladıkları ders planları ve derslerde kullandıkları öğretim stratejileri le ilgiliydi. İkinci soru ise öğretmenlerin teorik bilgileri ve uygulamaları arasındaki farklılıklar ile ilgiliydi. Bu sorulara cevap vermek üzere farklı veri kaynaklarından oluşturulan veriler yorumlayıcı içerik analizi ve yorumlayıcı olgubilimsel analiz ile analiz edildi.

Bulgular veri kaynaklarında öğretmenlerin kullandıkları öğretim stratejilerinin kodlanması ve kategorize edilmesi ile elde edildi. Kodlamalarda diğer benzer çalışmalardaki kodlamalara benzerlik dikkat çekicidir ancak bu çalışmadaki katılımcıların üst düzey br argümantasyon bilgisine sahip oldukları düşünüldüğünde kodlamalardaki önemsiz gibi görünen farklılıklar önem kazanmaktadır. Diğer bir deyişle, bu çalışmada yapılan kodlamalar önceki çalışmalarda yapılan kodlamalardan çok daha ayrıntılıdır ve bu yöndeki çalışmalara yön gösterebilecek şekilde detaylandırılmıştır. Ancak öğretmenlerin farklı yaş seviyelerinde gruplarla ders yapması, farklı uzunlukta dersler yapmaları, öğrenci sayılarının farklılığı, ders içeriklerinin farklılığı ve öğretmenlerin derslerini planlamada ve uygulamada belirli bir sisteme zorunlu olmamaları nedeniyle bu kod ve kategorilerin sıklığı ile ilgili herhangi bir değerlendirme yapılmamıştır.

Sonuç olarak altı farklı üst kategoride alt kategoriler ve kodlar ortaya çıktı. Bu kategoriler ve kodlar şu şekildedir:

Argümantasyona yönelik pedagojik bilgi (APB); APB öğretmenlerin ders planlarında ve uygulamalarında doğrudan argümantasyonu hedef alan öğretim stratejileridir. Bu üst kategorideki kodlar Simon, Erduran ve Osborne (2006) ve Mork (2005) tarafından yürütülen çalışmalarla benzer şekilde kodlanmıştır. Bu kategoride yer alan kodlar Tablo 1'de verilmektedir.

Argümantasyona yönelik üst düzey pedagojik bilgi (A-ÜPB); A-ÜPB öğretmenlerin ders planlarında ve uygulamalarında doğrudan argümantasyonu hedef alan ancak üst düzey düşünme becerisi gerektiren öğretim stratejileridir. Başka bir deyişle, APB'den farkı bu bilginin öğretmenin özellikle bu strateji üzerinde düşünmesi, planlaması ve bu yönde davranış sergilemesidir. Bu üst kategorideki kodlar Simon, Erduran ve Osborne (2006) ve Mork (2005) tarafından yürütülen çalışmalarla benzer şekilde kodlanmıştır. Bu kategoride yer alan kodlar Tablo 2'de verilmektedir.

Genel pedagojik bilgi (GPB); GPB doğrudan argümantasyonu hedef almayan ancak argümantasyon ortamını kolaylaştıran destekleyici öğretim stratejilerini içermektedir. Araştırmacılar bir stratejnin GPB olup olmadığını öğrenme ortamını göz önüne alarak değerlendirebilirler. Bu değerlendirme özellikle dersin hangi aşamalarında öğretmenin argümantasyonu hedeflediği dikkate alınarak yapılabilir.

Tablo 1. APB üst kategorisinde yer alan alt kategori ve kodlar

Alt kategori	Öğretim Stratejileri
Doğruluğunu sorgulama	Başka şekilde ifade etmek ve soruyu başka gruba yönlendirmek
	Açıklama istemek
Karşı argüman/ müzakere	Müzakereyi teşvik etmek
	Ön görülen karşı argümanı teşvik etmek
Argümanları değerlendirme	Süreci değerlendirmek- delil kullanımı
Öğrencileri dahil etme	Soruyu belli bir kişiye ya da gruba yöneltmek
Delille gerekçelendirme	Delili kontrol etmek
	Gerekçe istemek
	Şeytanın avukatını oynamak
	Delil sağlamak
Konumlandırma	Farklı duruşlara değer vermek
	Fikirleri teşvik etmek
Argümantasyon süreci üzerine yansıtma	Fikir değişikliği olup olmadığını sormak
Konuşma ve dinleme	Tartışmayı teşvik etmek
	Dinlemeyi teşvik etmek

Tablo 2. A-ÜPB üst kategorisinde yer alan alt kategori ve kodlar

Alt kategori	Öğretim Stratejileri
Argümanları değerlendirme	Argümanları değerlendirmek
	Beklentiler oluşturmak
Müzakere tekniğine odaklanma	Kurallar koymak
Argümantasyonun anlamını bilme	Belirli bir strateji seçme/ tanımlama
	Kazanımları/ amaçları belirleme

Genel üst düzey pedagojik bilgi (G-ÜPB); G-ÜPB öğretmenlerin ders planlarında ve uygulamalarında üst düzey düşünme becerisi gerektiren öğretim stratejileridir. GPB'den farkı bu bilginin öğretmenin özellikle bu strateji üzerinde düşünmesi, planlaması ve bu yönde davranış sergilemesidir. A-ÜPB'den farkı ise doğrudan argümantasyonu hedef almayan ancak argümantasyon ortamını kolaylaştıran destekleyici öğretim stratejilerini içermesidir.

Üst bilişsel stratejik bilgi (ÜBSB); ÜBSB bazı bilişsel beceriler ile ilgili genel bilgileri kapsar. Bu bilişsel bilgilere örnek olarak “bir düşünme stratejisine ilişkin genelleme yapma ve kurallar oluşturma, bir düşünme stratejisini tanımlama, bir düşünme stratejisinin ne zaman, neden ve nasıl kullanılacağını açıklama, ne zaman kullanılmayacağını açıklama, doğru stratejileri kullanmamanın olumsuz yönlerini açıklama, ve hangi durumların o stratejinin kullanımını gerektireceğini açıklama” verilebilir (Zohar, 2006; Zohar, 2008, p. 254; Zohar, 2012).

Bu çalışmada öğretmenlerin kullandıkları üst bilişsel stratejik bilgiler şunlardır: bir düşünme stratejisine ilişkin kurallar oluşturma (nedensel ilişkiler kurma), bir düşünme stratejisine ilişkin genelleme yapma (tahmin yürütme) ve bir düşünme stratejisini modelleme (karar verme).

Argümantasyona yönelik üst bilişsel stratejik bilgi (A-ÜBSB); A-ÜBSB doğrudan argümantasyona yönelik bazı bilişsel beceriler ile ilgili genel bilgileri kapsar. Bu çalışmada öğretmenlerin kullandıkları argümantasyona yönelik üst bilişsel stratejik bilgiler şunlardır: bir düşünme stratejisine ilişkin kurallar oluşturma (argüman oluşturma), bir düşünme stratejisini modelleme (argüman oluşturma, delillerin koordinasyonu, gerekçe gösterme) ve bir düşünme stratejisini tanımlama (argüman oluşturma).

Bu çalışmada ayrıca belirlenen öğretim stratejileri öğretmenlerin ders planlarında ve uygulamalarında argümantasyon dersi süresince nasıl dahil ediliyor sorusuna cevap aranmıştır.

Genel olarak, öğretmenlerin derslerinde öğrencilerin argüman oluşturmalarını kolaylaştırmak için bir yazı şablonu ya da çalışma kağıdı şeklinde yazılı eğitim materyali kullandığı görüldü. Öğretmenlerin tamamı öğrencilerin iddialarını desteklerken yararlanmaları için ders planlarında ve uygulamalarında bilimsel ifadeler, grafikler, şekiller ya da deneysel veri şekilinde deliller sundular. Üst düzey öğretim stratejilerinin olması, öğretmenlerin argümantasyon uygulamalarında ilgili kuramsal ve pedagojik bilgilerini planlı bir biçimde kullandıklarını gösterdi. Ancak, üst-düzey bilişsel bilginin ders planlarında taranması mümkün olmadığından, yalnızca ders uygulamalarında bu kategoride öğretim stratejileri görüldü.

Bütün ders uygulamalarında öğretmenlerin şu öğretim stratejilerini sıklıkla kullandığı görüldü: öğrencinin iddiasını, argümanını ya da gerekçesini açıklamasını istemek, öğrenciden gerekçe sunmasını istemek, karşı argümanı ve müzakereyi desteklemek, farklı fikirlerin dikkate alınmasını teşvik etmek. Öğretmenlerin tamamı ayrıca ön görülen karşı argümanı teşvik etmek, süreci değerlendirmek ve farklı duruşlara değer vermek olarak kodlanan öğretim stratejilerini ders uygulamalarında kullandılar. Argümantasyona yönelik pedagojik bilgi kategorisinde kodlanan öğretim stratejileri öğretmenlerin tamamı tarafından ders uygulamalarında gösterilmiş olsa da üst düzey argümantasyona yönelik pedagojik bilgi ve argümantasyona yönelik üst bilişsel stratejik bilgi kategorilerinde yer alan öğretim stratejilerini her öğretmenin gösterdiği söylenemez. Örneğin yalnızca üç derste öğretmenlerin bir öğretim stratejisine yönelik kurallar oluşturduğu, ve beş derste bir düşünme stratejisini modellediği görüldü.

Ancak belirli bi öğretim stratejisinin öğretmen tarafından gösterilmiş olması ya da bir öğretim stratejisinin hangi sıklıkla öğretmenin derslerinde görüldüğü bir dersin argümantasyon açısından etkili olup olmadığını söylemek için kullanılamaz. Ayrıca benzer şekilde öğretim stratejisinin görülme sıklığı incelenerek yapılacak araştırmalar bir öğretmenin dersleri arasında argümantasyonun etkili olup olmadığı açısından bir değerlendirme yapmak için ya da öğretmenler arasında böyle bir karşılaştırma yapmak için kullanılması doğru değildir. Çünkü derslerin içerikleri, dersin süresi, dersin yürütüldüğü sınıftaki öğrencilerin yaş grubu, öğrenci sayısı farklıdır. Ayrıca öğretmenin dersi planlarken format ve içerik konusunda özgür bırakılmış olması, bu yönde bir telkin ya da şablon öğretmenlere verilmemiş olması vb nedenlerle bir derste öğretmenin uyguladığı öğretim stratejileri üzerinden yapılan dersin argümantasyon açısından etkili olup olmadığı değerlendirilemez.

Bu çalışmadaki amaç böyle bir karşılatırma ya da değerlendirme yapmak değildir. Bu çalışmanın amacı öğretmenlerin fen bilimleri derslerinde gösterdikleri öğretim stratejilerini ortaya koymaktır. Bu stratejilere bakarak yapılabilecek değerlendirmelerden biri, Simon, Erduran ve Osborne (2006) tarafından ifade edildiği gibi öğretmenin kullandığı öğretim stratejisi ile belirli bir düşünme ya da argümantasyon becerisini önemsediğini göstermesi ve bu beceriyi öğrencilere kazandırmaya çalıştığıdır. Örneğin, “karşı argümanları teşvik etmek” gibi bir öğretim stratejisini öğretmen dersinde gösteriyorsa bu durum, öğretmenin karşı argüman oluşturma becerisini argümantasyon açısından önemli gördüğünü ve teşvik edilmesi gerektiğini düşündüğünü gösterir.

Özet olarak, bu çalışmaya katılan öğretmenler argümantasyona dayalı fen bilimleri derslerini uygulayabilmek için geniş bir çerçevede yer alan (altı üst kategoride) öğretim stratejileri kullandılar. Bu öğretim stratejilerinin ortaya konulması, öğretmenlerin hali hazırda sıklıkla kullandıkları- genel pedagojik bilgi kategorisinde yer alanlar gibi- öğretim stratejilerinin yanısıra argümantasyona yönelik dikkatli ve bilinçli bir şekilde planladıkları ve uyguladıkları öğretim stratejileri olduğunu gösterdi. Bilinçli olarak uygulanan bu stratejiler üst düzey pedagojik bilgi ve üst bilişsel stratejik bilgi kategorileri oluşturdu. Bu kategoriler bu çalışmanın önemli bir sonucudur çünkü Zohar ve David (2008) tarafından da belirtildiği üzere özellikle üst bilişsel kategoride yer alan stratejilerin kullanımının, başarı düzeyi düşük olan öğrencilerin dahi araştırma-sorgulama yoluyla bilim öğrenimi üzerine önemli etkisi vardır. Bu nedenle, bu stratejilerin belirlenmesi ve çalışmalarla teşvik edilmesi önem kazanmaktadır.

4.3. Sonuç ve Öneriler

Çalışmanın bu bölümünde araştırılan iki soru bulunmaktadır. Birinci soruda bu çalışmaya katılan öğretmenlerin argümantasyona dayalı fen bilimleri derslerini planlarken ve uygularken kullandıkları öğretim stratejilerini belirlemek amaçlanmıştır. Bu çalışmada özellikle öğretim stratejilerine odaklanıldı çünkü Davis ve Krajcik (2005) tarafından da belirtildiği üzere öğretim stratejileri öğretmenlerin pedagojik bilgilerinin önemli bir bölümünü oluşturmaktadır. Argümantasyona dayalı fen bilimleri dersleri planlayabilmek ve uygulayabilmek için ise bilimsel argümantasyonun ne olduğunu bilmek yeterli değildir (McNeill & Knight, 2013), öğretmenlerin argümantasyonu uygulayabilecekleri öğretim stratejilerini de bilmesi gereklidir. Bununla birlikte öğretim stratejilerini bilmek her zaman bu stratejilerin sınıf içi uygulamalarda kullanılabileceğini göstermez. Öğretim stratejileri açısından bilgi yanında öğretmenler argümantasyona dayalı fen bilimleri derslerinde deneyim de kazanmalıdırlar (Davis & Krajcik, 2005).

McNeill ve Knight (2013) argümantasyon konusunda deneyim kazanmış öğretmenlerin, öğrencilerin davranış ve ilişkileri üzerine de odaklanabilecekleri başka öğretim stratejilerinde de yeterlik kazanabileceğini belirtmektedirler. Bu tür öğretim stratejileri bu çalışmada yer alan öğretmenlerin uygulamalrında ortaya konulmuştur. Örneğin öğretmenler çalışma kağıtlarında ya da argümantasyon esnasında öğrencilerin kurdukları argümanları tespit edebilme ve nitelik açısından değerlendirebilme yeterliliğini, ve öğrencilerin argüman oluştururken ampirik gerekçeleri kullanıp kullanmadıklarını değerlendirebilme yeterliliğini kazandılar (McNeill & Pimentel, 2010); öğrencilerini daha fazla delil öne sürerek ve farklı görüşleri de dikkate alarak argümanları geliştirebilmeleri yönünde teşvik edebildiler (Simon, Erduran & Osborne, 2006); derslerinde argümantasyonu pekiştirecek belirli öğretim stratejileri kullanarak, örneğin açık uçlu, probleme dayalı durumlar ya da sorular oluşturarak, argümantasyona dayalı öğrenme etkinliklerini planlayabildiler ve uygulayabildiler (Berland & Hammer, 2012; Berland & McNeill, 2010; Berland & Reiser, 2009); öğrencilerin birbirlerini dinledikleri, argüman oluşturdukları ve fikirleri sorguladıkları öğretim ortamları oluşturabildiler (McNeill & Knight, 2013). Ayrıca ders video kayıtları öğrenciler argümanlarını ya da karşı argümanlarını gerekçelendirirken zorluklar yaşadıklarında, öğretmenlerin argümantasyonu farklı ya da benzer örneklerle modelleyebildiklerini gösterdi (McNeill, 2009). Sonuç olarak, bu çalışmanın bulgularına dayanarak, yansıma yoluyla desteklenmiş döngüsel uygulamaların, öğretmenlerin argümantasyona dayalı fen bilimleri derslerini planlama ve uygulamada uygun öğretim stratejileri geliştirmelerini desteklediğini söyleyebilirim.

Çalışmanın bu bölümünde cevap aranan ikinci soru öğretmenlerin argümantasyona dayalı fen sınıfı uygulamalarında kuramsal bilgileri ve uygulamaları arasındaki farklılıklar nasıl ortaya konulduğu ile ilgiliydi. Araştırmalar mesleki gelişim programlarının öğretmenlerin belirli öğretim stratejilerini pedagojik bilgilerine dahil etme ve bunları derslerinde kullanmaları konusunda yardımcı olduğunu göstermektedir (Borko, 2004; Jeanpierre, Oberhauser, & Freeman, 2005). Benzer şekilde bu çalışmada da geliştirilen yükseköğretim dersinin öğretmenlerin fen bilimleri eğitiminde argümantasyon teorisi konusunda anlayış geliştirmesini sağladığı ve öğretmenlerin argümantasyona dayalı fen bilimlerini fen sınıflarında uygulamaları için olanak yarattığı görüldü. Argümantasyona yönelik yüksek lisans dersi sonunda, öğretmenlerin yansıtıcı eleştirileri ve eleştirel yazıları öğretmenlerin fen bilimleri eğitiminde argümantasyon teorisi konusunda bilgilerini yansıtabilecekleri bir öğrenme ortamını planlama ve uygulamanın oldukça zor olduğunu belirttiler. Dolayısıyla öğretmenlerin eleştirileri, McNeill ve Knight (2013)'ın da belirttiği gibi öğretmenlerin argümantasyona dayalı fen bilimleri dersi yapabilme hususunda daha fazla deneyime, desteğe, geri bildirime ve aynı zamanda daha fazla kaynağa ve materyale ihtiyaç duyduğu gerçeğini desteklemektedir.

Bu çalışmanın sonuçları göz önüne alınarak özetle şu öneriler geliştirilebilir:

1. Bu çalışmada geliştirilen ve ayrıntılandırılan öğretim stratejileri öğretmenlerin argümantasyona dayalı fen bilimleri derslerini planlarken ve uygularken ortaya koydukları stratejilerdir. Bu stratejilerin araştırılmış olması araştırmacılar için bir kaynak oluşturabilir. Öğretim stratejilerini incelemek öğretmenlerin argümantasyona dayalı fen derslerinde argümantasyonun hangi yönlerini derslerine ilişkilendirmekte zorlandıklarını ya da öğrencilerine kazandırmakta zorlandıklarını ortaya koyabilir. Aynı şekilde öğretmenlerin argümantasyonun hangi yönlerini anlamlı bulduğunu ve daha fazla önemsediğini de açığa çıkarabilir. Böylece araştırmacılar argümantasyona

yönelik öğretmen eğitimi planlarken ve uygularken bu bilgileri göz önünde bulundurabilirler.

2. Bu çalışma ayrıca öğretmenlerin argümantasyon bilgisinin sınıf içi uygulamalarına nasıl yansıdığını anlamak açısından önemlidir. Çalışmanın bulgularının özellikle öğretmen eğitimi açısından önemli sonuçları vardır. Örneğin, bu çalışma ile öğretmen eğitiminde uygulamanın önemi bir kez daha ortaya konulmuştur. Ancak daha önemlisi hangi seviyede olursa olsun her öğretmenin kuramsal bilgilerini uygulamaya yansıtmada desteğe ihityacı olabileceğini göstermektedir. Bu çalışmada öğretmenler yüksek öğrenim görmekte olan ve bu nedenle üst düzey argümantasyon bilgisi edinen öğretmenlerdi. Öğretmenlerin argümantasyonu öğrenme süreci yalnızca alan yazında yer alan çalışmalarla değil aynı zamanda doğrudan argümantasyonla ilgili deneyim kazandıkları etkinliklerle ve hem alan yazının hem de etkinliklerin üst düzeyde tartışıldığı öğrenme ortamları ile desteklendi. Ancak öğretmenlerin argümantasyonla ve fen eğitimi ile ilgili pedagojik anlayışlarındaki değişimde bu öğrenme ortamından daha fazla kendi sınıf içi uygulamalarının etkisi olduğu görüldü. Bu sonuçların özellikle öğretmen eğitimi açısından önemli olduğu açıktır.
3. Araştırma açısından bu çalışmanın yönteminin de araştırmacılar için bir kaynak oluşturabileceği düşünülmektedir. Çünkü bu çalışmada uygulanan eğitim tasarımı araştırması daha önce fen bilimleri öğretmen eğitiminde örnekleri çok az olan ancak bu çalışma ile etkililiği büyük ölçüde ortaya konulan bir araştırma desenidir. Ayrıca çalışma süresince öğretmenlerin kendilerini mümkün olan en fazla yöntemle ifade etmeleri dikkate değer bir uygulamadır. Öğretmenlerin yaptığı yansıtıcı eleştiriler ve geri bildirimler eğitim tasarımının son halinin verilmesinde özellikle etkili olmuştur. Ayrıca bu bildirimler öğretmenlerin kullandıkları öğretim stratejilerinin belirlenmesinde de oldukça önemlidir. Çünkü bu bilgi, öğretmenlerin duruma bakış açısını bilmek ders anında öğretmenin ne düşündüğünü bilmek, öğrenme ortamını anlayabilmek ve değerlendirebilmek ve buna göre öğretim stratejisini tanımlayabilmek açısından çok değerlidir. Bunlara ek olarak, bu çalışmadaki öğretmenlerin argümantasyon konusunda üst düzey kuramsal bilgiye sahip oldukları göz önüne alındığında, bu çalışmada yer alan öğretmenlerin görüşleri kuramsal bilgilerin bu çalışma sınırlılıkları dahilinde hangi düzeyde uygulamaya yansıtılabileceğini göstermesi açısından da önem kazanmaktadır. Bu nedenle öğretmenlerin görüşlerine mümkün olan en üst düzeyde yer verilmesi önemli bir veri kaynağıdır.

4.4. Çalışmanın sınırlılıkları

1. Bu çalışmaya katılan öğretmen grubu bir çok özelliği nedeniyle genel öğretmen profilinden ayrılmaktadır. Bu çalışmada yer alan öğretmenler, ya yüksek öğrenim görmekte olan- yüksek lisans ve doktora- öğretmenlerdir ya da yüksek öğrenim görmekte olan ve ileride eğitim araştırmacısı olacak, öğretmen yetiştirme konusunda uzmanlaşan araştırmacılardır. Bu çalışmada geliştirilen ders bir seçmeli ders olarak verildiğinden dersi almaları tamamen kendi istekleri doğrultusunda olmuştur. Öğretmenler disiplinleri açısından da homojen bir grup değildir. Öğretmenlerden beşi fen bilgisi eğitiminde, diğer ikisi kimya eğitiminde yüksek lisans-doktora yapmaktadır. Öğretmenlerin uygulamayı yaptıkları öğretim kurumları da biribirinden farklıdır. Örneğin özel etüt merkezinde, dershanede, özel okulda, devlet okulunda ya da üniversitede ders veren öğretmenler bu çalışmada yer almışlardır. Dolayısıyla her ne kadar bu çalışmanın sonuçlarını genelleme gibi bir amaç olmasa da araştırmacılar öğretim stratejilerinin başka durumlar için geçerli olup olmayacağını sorgulayabilirler. Bu değerlendirmeyi araştırmacıların yapabilmesi için çalışmada yer alan gruba dair tüm özellikler, ayrıca araştırmanın her aşaması olumlu ve olumsuz, aksayan ve işleyen tüm yönleri, çalışmaya katıan öğretmenlerin olumlu olumsuz tüm yansıtıcı eleştirileri ve geribildirimleri ile araştırmacı ve eğitimci olarak benim de düşünümsellik yoluyla deneyimlerimin tüm ayrıntıları açıkça paylaşılmıştır.
2. Çalışmanın öğretim stratejilerinin kodlanması aşamasında öğretmenlerle görüşme imkanının olmaması bu çalışmayı öğretim stratejilerinin kodlanmasının öğretmenlerin yansıtıcı eleştirilerine dayanan ve ancak araştırmacı olarak benim yorumlamam ve uzman görüşleri olması nedeniyle sınırlandırmaktadır. Bu anlamda araştırmacılara önerim benzer çalışmalarda kodlamaların değerlendirilmesi için katılımcı öğretmenlere o anda neyi amaçladıklarını sormaları ve geri bildirim almalarıdır. Bu geri bildirim kodlama sürecini daha kolay ve sağlıklı yürütmeyi sağlayabilir.

5. Öğretmenlere Argümantasyon Öğretme Deneyimi: Otoetnografik Çalışma

Bu bölümde araştırmacı ve eğitmen olarak fen bilimlerinde argümantasyon öğretimi ve araştırması ile ilgili benim deneyimlerim aktarıldı. Böyle bir çalışmanın amacı bir araştırmacı olarak benim kuramsal ve uygulama arasında yaşadığım farklılıkları ve ayrıca öğretmen eğitimi alanında uzmanlaşan eğitimci olarak bu çalışmada yaşadığım zorlukları ve olumlu deneyimleri ortaya koymaktır. Çalışmanın bu bölümü analitik otoetnografik bir araştırma olarak yürütüldü. Bu nedenle bu bölümde deneyimler eleştirel bir bakış açısıyla kendimle ilgili yaptığım gözlemlerden ve düşünümsel incelemelerden oluşmaktadır.

5.1. Analitik Otoetnografi

Otoetnografi araştırmacının kendi deneyimlerini içinde bulunduğu kültürel, politik ve sosyal anlam ve anlayışlar içinde değerlendirdiği bir araştırma yöntemidir (Maréchal, 2010). Çalışmanın bu bölümünde Anderson (2006) tarafından ortaya konulan analitik otoetnografi yöntemi kullanıldı. Anderson(2006) analitik otoetnografinin özelliklerini üç maddede toplamaktadır: “(1) araştırmacı araştırdığı grubun ya da ortamın tamamen içindedir, bu ortamın bir üyesidir, (2) araştırmacının bu durumu yaptığı tüm yayınlarında açıkça görülür ve (3) araştırmacı daha geniş bir sosyal olgunun teorik olarak daha iyi anlaşılmasına yönelik analitik bir araştırma yöntemi izler” (Anderson, 2006, s.375). Araştırmacının analitik otoetnografinin bu özelliklerine uygun olarak araştırmacının araştırdığı sosyal ortamın bir ögesi olması, yayınlarında analitik düşünümselliği öne çıkarması ve araştırma ortamının bir ögesi olarak kendi durumunu açıkça ortaya koyması, kendinden başka kişilerden de kendisi hakkında görüş alması ve araştırdığı sosyal olguya ilişkin kuramsal bir katkıda bulunmayı araştırmada temel alması gereklidir. Dolayısıyla bu çalışmada ben aynı zamanda araştırdığım ortamın bir üyesiydim, bir öğrenendim ve bu nedenle kendimi de araştırmada bir veri kaynağı ve analiz edilecek bir veri olarak görmekteyim. Çalışmada analitik otoetnografinin yer almasının en önemli gerekçesi bu durumdur.

5.2. Veri kaynakları

Bu bölümde kullanılan veri kaynakları şu şekilde sıralanabilir:

1. Kendime dair gözlemlerim ve kendime dair yansıtıcı kayıtlar: Bu çalışmada fen öğretimi ve öğreniminde argümantasyona ilişkin yüksek lisans dersinin ses ve video kayıtları benim araştırdığım sosyal ortamda kendimi gözlemlemem için kullanıldı. Ayrıca içinde bulunduğum kültürel kimlik ve kültürel aidiyet sınırlılıkları içinde kendi kişisel ve mesleki değerlerime ilişkin bildirimlerde bulundum. Ayrıca benim hakkımda diğer katılımcıların görüşlerini yazdıkları geri bildirimler ve son görüşmelerden elde ettim.

2. Harici veriler: Bu veriler aynı sosyal ortamı paylaştığım katılımcı olarak yer almayan ancak sosyal ortamın bir üyesi olarak o ortamı gözlemlemek üzere ortamda bulunan bir meslektaşımın görüşlerinden elde edildi.
3. Klinik danışman görüşü: Ortamı gözlemlemek ve tartışmalara katılmak üzere ortamda bulunan tez danışmanımın görüşlerinden elde edildi.

5.3. Çalışmanın İnandırıcılığı

Çalışmanın inandırıcılığı için Struthers (2012) tarafından yapılan analitik otoetnografi çalışmasında kullanılan yöntemler izlendi. Guba ve Lincoln (1989, alıntı Struther, 2012, s.79) tarafından önerilen bu yöntemler şöyle sıralanabilir: adillik/ dürüstlük (fairness), ontolojik gerçeklik (ontological authenticity), eğitici gerçeklik (educative authenticity) ve katalitik gerçeklik (catalytic authenticity).

5.4. Bir araştırmacı olarak deneyimlerim

Bir araştırmacı olarak bu süreçte yer alan deneyimlerim daha çok kuramsal ve felsefik bilgilerimin gelişmesi ve değişmesi yönündeydi. Örneğin, öğretmenlerin öğrenmesinin aynı öğrenci öğrenmesi gibi olabileceği ya da sırasıyla takip edilebilecek doğrusal ilerleyen aşamaları olan bir öğretimin öğretmen eğitimi için etkili olabileceğini düşünmekteydim. Bu çalışmanın planlanması aşamasında (analiz ve keşif) öğretmen eğitiminin farklı kuramları olan bir alan yazın olduğunu ve bu alan yazında dönüşümsel öğretmen eğitimi teorisinin benim bu çalışmadaki amaçlarımı gerçekleştirmede en uygun öğretmen eğitimi teorisi olduğunu öğrendim.

Ayrıca bir araştırmacı olarak öğretmen eğitimi ile ilgili planlamanın ve uygulamanın zorluklarını yaşadım ancak böyle durumlarda hedefleri terketmeden içinde bulunduğum durumu araştırma açısından daha verimli hale nasıl getirebilirim, hangi kaynakları kullanabilirim, hangi yöntemler etkili olur gibi planlamaları önceden ve kısa zamanda uzmanlara danışarak ele almayı öğrendim.

Zaman zaman kendi bilgimin, yeteneklerimin ve uzmanlık alanımın dışında yer alan eğitim yazılımları geliştirme ve kullanma gibi yöntemler belirledim. Bununla birlikte, belirlediğim bu yöntem başarısız oldu çünkü zamanında ve yeterli kaynağı bu konuda yönetemedim, ilgili olabilecek kişilere ulaşmam düşündüğümden çok daha maliyetli oldu, uzmanlardan bu konuda yardım almak için ve uygulamaya koymak için zaman yönetiminde sıkıntılar yaşadım. Ancak bir araştırmacı olarak yine de bu yöndeki hedeflerimden uzun süre vazgeçtiğimi söyleyemem.

Denemelerimin tamamı başarısız olduğunda bu yöntemi bu çalışma için terketmem gerektiğinde üzülerek gereğini yaptım ve durumu bu yöntem olmadan da en etkili hale nasıl getirebilirim üzerine düşündüm ve bu yönde eğitim tasarımını güncelledim.

Bir ders planlamanın ve yürütmenin bir ders programı yapmaktan çok daha fazla emek isteyen bir iş olduğunu gördüm. Öğretmenlik yaparken ya da mevcut bir öğretim programını uygularken kendimi düşünmek zorunda hissetmediğim çok önemli konular olduğunu farkettim. Örneğin ben bu dersi planlarken öğrenme ile ilgili benim anlayışım, dersin amaç ve yöntemlerini belirlemede bana yol gösterecek öğrenme ile ilgili felsefi varsayımlarım nelerdi? Bu öğrenme ile ilgili varsayımlar derse nasıl yansıyacaktı? Bunların dışında benim bir araştırmanın amaç ve yöntemlerine ilişkin felsefi varsayımlarım nelerdi? Benim görüşüme göre bir araştırmanın hedefi ne olmalıydı ve bu hedefe ulaşmak için hangi yöntemler izlenmeliydi? Argümantasyon ile ilgili farklı tanımlar ve farklı hedeflerle karşılaştığımda, ben argümantasyonu hangi açıdan anlıyorum ve argümantasyonu hangi felsefi akımla ilişkilendiriyorum sorusunu sormam gerekti. Bütün bu sorular bir ders planlama ya da araştırma yapmanın önceliği olarak karar verilmesi gereken konulardı ve beni üzerinde uzun süre araştırma yapmaya, düşünmeye ve tartışmaya zorladı.

5.5. Bir eğitimci olarak deneyimlerim

Bir eğitimci olarak öğretmen yetiştirme alanında daha önceden proje ve dersler aracılığıyla deneyim kazanmıştım. Ancak bu çalışma bir yüksek lisans dersi olması nedeniyle tamamen farklı bir deneyimdi. Çünkü yüksek lisans dersine gelen hedef grup hem nitelikleri ve yaş grubu açısından benimle aynı ve bazı yönlerden- öğretmenlik deneyimi, bilim felsefesi konusundaki bilgileri- daha ileri düzeydeydi, hem de öğrenme ile ilgili hedefleri ve beklentileri öğretmen adaylarından ve hizmet içi diğer öğretmenlerden daha farklıydı. Bu çalışmaya katılan öğretmenler tamamen bilinçli olarak, argümantasyon teorisine ilişkin üst düzey bilgi edinmek ve tartışmalarda bulunmak üzere ve hatta ileride belki de bu yönde bir araştırma yapabilecek düzeyde bilgi ve deneyim sahibi olmak üzere bu derse kendi istekleri doğrultusunda kayıt yaptırdılar. Böyle bir grupla çalışmanın bir eğitimci olarak öğretim ortamıyla ilgili algılarımda diğer gruplara yönelik olanlardan farklı bir algı olması gerekliydi. Bu öğrenme ortamında ben bir lider, bir rehber ya da bir öğretmen olarak yer almaktan ziyade, rolümü bu öğrenme ortamının bir üyesi olarak belirledim. Öğrenme ortamına bakış açım bilgi ve deneyimlerimi paylaşmak ve tartışma soruları ile okumalara ve deneyimlere yönelik akademik ve felsefi düzeyde tartışmalar yapmaya katkıda bulunmak şeklindeydi. Bu bakış açısının özellikle öğretmenlerin öğretmenlik deneyimi, felsefe bilgisi, kişisel deneyimleri gibi yönlerden benim düşüncelerimden ve anlayışlarımdan farklılık gösterdiği durumlarda çok yardımcı olduğunu söyleyebilirim. Böyle durumlarda ben de bir öğrenen olarak öğretmenlerin paylaşımlarını izledim, tartışmalara katıldım, sorular sordum ve kendi bilgi ve anlayışımı sorguladım.

Ortamdaki diğer gözlemcilerin ve aynı zamanda katılımcıların yaptıkları geri bildirimlerden öğrenme ortamının kalitesinin, etkililiğinin ve öğrenmeye ve özgürce tartışmaya fırsat vermesinin takdir topladığını gördüm.

Bazı derslerde program dışı tartışmalar oldu ve bu tartışmaların uzaması bazı katılımcıların derse motivasyonunu düşürdü ve ders sürecinin takip edilmesini zorlaştırdı. Böyle haftalarda sınıfta bulunan diğer katılımcı-gözlemcinin, tez danışmanımın ve diğer katılımcıların geri bildirimleri bir eğitimci olarak benim süreci özetleyerek tekrar diğer katılımcıların motivasyonunu yükseltecek etkinlik ve tartışmalara dönmemi sağladı. Bu deneyim bir eğitimci olarak öğrenenlerin geri bildirimlerinin ve bu geri bildirimleri dikkate almanın önemini bir kez daha farketmemi sağladı.

5.6. Sonuç ve Öneriler

Çalışmanın bu bölümü analitik otoetnografinin bir araştırma yaklaşımı olarak benimsemesinin bir çalışmada araştırmacının ya da eğitimcinin bakış açısını da ortaya koyması açısından önemini vurgulamaktadır. Çünkü yapılandırıcı-yorumlayıcı yaklaşımda araştırmacı araştırmanın bir ögesidir. Dışardan bir gözlemci ya da tarafsız tutum sergilemeye çalışmak bu anlayışa göre mümkün değildir. Bu çalışmada da ele alınan yaklaşıma göre etkileşime geçtiğimiz her durum ya da kişi üzerinde karşılıklı etkileşim oluştururuz. Bir başka deyişle, bir araştırmacının örneğin bir görüşmede katılımcının verdiği cevapları ortamdan bağımsız değerlendirmesi mümkün değildir çünkü araştırmacının o anda soruyu sorarken takındığı tutum, soruyu sorma biçimi, görüşmenin yapıldığı ortam vb bir çok etken hem araştırmacıyı hem de katılımcıyı karşılıklı etkiler. Aynı şekilde bu çalışmada da benim de araştırdığım ortamın bir üyesi olarak varlığımın o ortamda yaptığı etkilerden bağımsız bir çalışma ortamı anlatmam ya da benim bir araştırmacı ya da bir eğitmen olarak bu ortamdan etkilendiğimi ve ortamı etkilediğimi inkar etmem yersizdir. Böyle bir anlatım çalışmanın çok önemli bir etkeni olan benim varlığımı inkar etmek olacaktır. Dolayısıyla çalışma süresince benim ortamdaki varlığımı açık ve dürüst olarak ortaya koymam bu çalışmanın sonuçlarını değerlendirmede diğer araştırmacılar için bir referans olmaktadır.

Ayrıca benim bu çalışmada bir araştırmacı ve eğitimci olarak deneyimlerim benzer bir çalışma yürütmek isteyen araştırmacılara ya da eğitimcilere yaşayabilecekleri zorluklar, bu zorlukların üstesinden nasıl gelebilecekleri, çalışmayı daha verimli hale nasıl getirebilecekleri konusunda bir kaynak oluşturmaktadır. Benim kişisel özelliklerimin, akademik açıdan durumlara bakış açımın, öğrenme ve araştırma ile ilgili felsefi görüşlerimin açık ve dürüst olarak ifade edilmesi aynı ya da farklı görüşleri paylaşan araştırmacılar ve eğitimciler için benzer bir eğitim tasarımı oluşturmada referans oluşturmaktadır.

I. TEZ FOTOKOPİSİ İZİN FORMU

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YAZARIN

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Adı : YASEMİN

Bölümü : İLKÖĞRETİM

TEZİN ADI (İngilizce) :

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