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This study explored the impact of explicit instruction on argumentation-based pedagogy, coupled with modelling and hands-on learning activities on pre-service physics teachers' perceived self-efficacy to teach science through argumentation. Participants consisted of 24 pre-service physics teachers attending an established teacher education program at a Turkish university. The results showed that the intervention had a positive impact on participants' self-efficacy to teach science through argumentation. More specifically, pre-service teachers who participated in this study: 1) viewed argumentation as a pedagogical tool that can help students to engage in meaningful learning, 2) reported high self-efficacy to teach science through argumentation and 3) indicated high motivation to teach science through argumentation in their future classrooms. In spite of these positive outcomes, participants shared their hesitations to teach science through argumentation as well. The implications of these findings for teacher education, teacher induction and future research are discussed.

Keywords: science teachers` beliefs, student teachers` beliefs, science teacher education in Georgia

INTRODUCTION

There has been an increasing emphasis on teaching science through argumentation in recent years (Newton, Driver & Osborne, 1999; Kuhn, 2010). As a result, research on argumentation in science education has intensified exponentially within the last decade (Bricker & Bell, 2008; Duschl & Osborne, 2002; Erduran & Jimenez-Aleixandre, 2008; Kelly & Chen, 1999; Sandoval & Millwood, 2008; 2005; Sampson & Clark, 2008; Simon, Erduran & Osborne, 2006; Zohar & Nemet, 2002). Argumentation refers to the process of proposing, supporting, criticizing, evaluating, and competing ideas using evidence, critical thinking and rationality (Kuhn, 1993). Proponents of argumentation maintain that argumentation based instruction is effective in promoting students' understanding of the nature of science (Sandoval & Millwood, 2005; Simon et al., 2006) and their conceptual understanding of core scientific ideas (Duschl & Osborne, 2002; Erduran & Jimenez-Aleixandre, 2008; Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Sampson & Clark, 2008; von Aufschnaiter, Erduran, Osborne & Simon, 2008; Zohar & Nemet, 2002). These scholars maintain that

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State of the literature

- Research indicates that science teachers rarely promote argumentation in their classes.
- Implementation of argumentation requires teachers having pedagogical content knowledge for teaching science through argumentation.
- Although research on argumentation has intensified for two decades, there is limited knowledge of science teachers' beliefs about and attitudes towards argumentation and their self-efficacy to teach science through argumentation.

Contribution of this paper to the literature

- By investigating pre-service science teachers' attitudes towards argumentation and their perceived self-efficacy to teach science through argumentation, we can gain invaluable insight into pre-service science teachers' learning needs in terms of their abilities to teach science through argumentation.
- This study is important in that there is substantial evidence on science teachers' limited pedagogical knowledge and skills to teach science through argumentation.
- Results of the current study is encouraging in that other science teacher educators can use similar interventions to enhance their students' self-efficacy to teach science through argumentation.

argumentation brings about such outcomes because it encourages students to engage in learning at a higher cognitive level as they are constantly engaged in questioning, justifying, substantiating and evaluating theirs and their peers' claims, rationality and knowledge (Erduran & Jimenez-Aleixandre, 2008).

Although the theoretical support for the use of argumentation in science classrooms is present, we have limited knowledge of best practices that can improve science teachers' attitudes towards the use of argumentation, their knowledge of argumentation pedagogy and their self-efficacy to teach science through argumentation. If we want argumentation-based pedagogy to prevail in science classrooms, we need to research and identify effective instructional strategies to increase science teachers' self-efficacy and motivation to teach science through argumentation. We designed this study to make contributions to these efforts. More specifically, we designed this study to explore the impact of explicit instruction on argumentation-based pedagogy, coupled with modeling and reflective teaching experiences on pre-service physics teachers' attitudes towards the use of argumentation in their classrooms, their beliefs about the perceived benefits of argumentation for students' learning of physics, and their perceived self-efficacy to teach science through argumentation.

This study is important for several reasons. First, there is substantial evidence in science education literature on difficulties that k-12 students face in formulating evidence-based scientific arguments (Abi-El-Mona & Abd-El-Khalick, 2006; Bell & Linn, 2000; McNeill, Lizotte, Krajcik & Marx, 2006; Sandoval & Millwood, 2008; Sampson & Clark, 2008). If we want our students to develop evidence –based scientific explanations we need to help their teachers to develop pedagogical knowledge, self-efficacy and motivation to teach science through argumentation. Second, most recent studies show that teachers do not understand the epistemological foundations of argumentation and that they have limited pedagogical knowledge and skills in designing learning activities to support their students' effective engagement with argumentation (Duschl & Osborne, 2002; Knight & McNeill, 2011; Kuhn, 2010; Sampson, 2009; Sampson & Blanchard, 2012; Simon et al., 2006).

Review of Literature

Argumentation is increasingly becoming popular among science educators in recent years. One of the reasons why argumentation is becoming popular among science educators is that that there is an intense effort by science educators to help students develop an adequate understanding of cognitive and sociocultural practices of the scientific community (Kuhn, 2010; Sampson, 2009; Sampson & Blanchard, 2012; Simon et al., 2006). Another reason why science educators place an increasing emphasis on the use of argumentation in science classrooms is that current literature on students' learning highlights the role of both cognitive and social activities in the process of knowledge construction (Bransford, Brown & Cocking, 2000). Meaning, argumentation-based learning engages students both in cognitive and social activities and processes that result in improved learning gains (Kelly & Chen, 1999; Kuhn, 1993; Newton et al., 1999). In addition, argumentation engages students in meaningful learning as it enables students' ownership over construction and the evaluation of knowledge and challenges them to justify their understandings (Kuhn, 2010; Newton et al., 1999; Simon et al., 2006).

In spite of the increasing advocacy for teaching science through argumentation, teachers rarely engage their students in argument construction and evaluation experiences (Abi-El-Mona & Abd-El-Khalick, 2006; Evagorou & Avraamidou, 2011; Knight & McNeill, 2011; Kuhn, 2010; Sampson, 2009; Sampson & Blanchard, 2012; Yerrick, 2000). The three most commonly cited reasons for the scarce use of argumentation in science classrooms are: 1) teachers do not have an adequate understanding of the role of argumentation in real life scientific practices, 2) teachers lack pedagogical knowledge and skills necessary to implement argumentation-based lessons in their classrooms, 3) teachers do not have access to resources that can help them to teach science through argumentation (Evagorou & Avraamidou, 2011; Sampson, 2009; Simon et al., 2006) and 4) the perceived pressures of mandated curriculum (Abi-El-Mona & Abd-El-Khalick, 2006; Sampson, 2009).

Science educators have invested a reasonable effort into developing curriculum resources (cf. Clark & Sampson, 2006; Osborne, Erduran, Simon, 2004; Sandoval & Reiser, 2004) for teachers to teach science through argumentation. Supporters of argumentation in science classrooms maintain that the implementation of these curriculum materials or instructional strategies advocated in current science education literature requires knowledgeable teachers that understand the theoretical assumptions underpinning scientific argumentation, value argumentation-based teaching as a way to promote meaningful learning in their classrooms and hold practical knowledge and skills to teach science through argumentation (Berland & Reiser, 2009; Erduran, Ardac, Yakmaci-Guzel, 2006; Knight & McNeill, 2011; Kuhn, 2010; McNeill et al., 2006; McNeill, 2009; Osborne, Simon, Howell-Richardson, Christodoulou, 2010; Sampson, 2009). As Erduran et al. (2006, p.3) state, "the execution of argumentation in real science classroom will demand more than rhetoric". It requires teachers who have sophisticated pedagogical knowledge to teach science through argumentation (Driver, Newton, & Osborne, 2000; Evagorou & Avraamidou, 2011; Knight & McNeill, 2011; Kuhn, 2010; Osborne et al., 2010; Sampson, 2009; Simon et al., 2006). In fact, the studies conducted by Erduran and colleagues in the UK, McNeill and Sampson in the U.S show that teachers who receive focused professional development can engage their students in argumentation more effectively than those who do not. We provide a review of these efforts in the next section.

Pre-service Science Teachers and Argumentation

Several science educators have conducted research on argumentation with pre-service and practicing science teachers. While some of these efforts have focused on science teachers' understanding of argumentation, pedagogical knowledge for teaching science through argumentation, others have focused on science teachers' practices related to argumentation-based science teaching.

Zembal-Saul (2005) conducted a study that focused on pre-service elementary science teachers' understanding of the role of argumentation in science. She found that placing emphasis on argumentation in science methods courses improved pre-service teachers' understanding of the importance of teaching science through argumentation. Her analysis showed that the pre-service elementary teachers who engaged in video case analysis of argumentation-based teaching placed an increased emphasis on role of evidence, explanation and argumentation in their teaching.

Erduran et al (2006) studied the growth of 17 pre-service chemistry teachers' abilities to use argumentation in their teaching. Erduran and colleagues trained 17 pre-service teachers with the IDEAs pack (Osborne et al., 2004) for six weeks as part of their methods/practicum course. By analyzing teacher talk, student group talk, students' written work, teachers' lesson plans and teachers' responses to the argumentation questions, they found that the majority of participants successfully promoted argumentation in their teaching. More precisely, the participants placed a greater emphasis on students' use of evidence, their abilities to relate evidence to claim and forming complex arguments involving warrants and backings as a result of their participation in the intervention activities.

In another study, Simon et al. (2006) studied classroom practices of 12 teachers who attended a six half-day workshop as part of the IDEAs project. The purpose of the project was to help teachers to develop instructional materials and strategies to support teaching science through argumentation (Simon et al., 2006). The workshop challenged teachers to discuss argumentation-based teaching activities that they implemented in their classrooms and shared their teaching experiences with each other. According to Simon et al (2006), two-thirds of the teachers improved their instructional practices after attending the workshops. More specifically, their analyses of participant teachers' first and last lessons showed that participants placed a greater emphasis on, "conveying the meaning of argument through modeling and exemplification, positioning oneself within an argument and justifying that position using evidence, constructing and evaluating arguments, exercising counter-argument and debate, and reflecting upon the nature of argumentation" (Simon et al. 2006, p.255).

Sampson (2009) conducted a study with 30 middle and high school teachers in Florida. The participants were selected from a wide range of backgrounds (science preparation, advanced degrees, student population served). Sampson explored participant teachers' attitudes towards argumentation through in-depth semi-structured interviews. He also assessed the participants' abilities to formulate a justification for three competing ideas in four different tasks. The assessment tasks focused on two physical science topics, one life science topic, and one earth space science topic. After he engaged the participants in evaluation of competing ideas, he asked them to explain their views of the potential value of engaging their students in these types of learning tasks on their meaningful engagement in science learning.

The results of his analyses showed that the majority of teachers failed to evaluate the competing ideas presented to them using the norms of science. He found that teachers developed answers based on the plausibility of the explanation and the fit between their existing conceptions and the explanation choice given to them in the tasks. The interesting finding was that 53% of the teachers (n=16) never used the data that were given to them and 26% (n=8) of them only used the data only during one of the tasks. The results showed that "only 20% (n=6) of the teachers in the study used the available data to evaluate the validity or acceptability of an explanation on a regular basis" (p.10). He found that although teachers failed to successfully develop evidence-based scientific arguments, they viewed argumentation as an effective instructional method for improving their students' understanding of core scientific ideas.

Abi-ElMona and Abd-El-Khalick (2006) studied three grade 10 high school classrooms taught by the same instructor to see the types of argument structures that were promoted in the classroom. They found that the students constructed weak arguments. That is, their arguments lacked warrants or supporting evidence. In their conclusions, the authors state that k-12 students need guidance and scaffolding in order for them to develop quality arguments. In fact, Herrenkohl & Guerra (1998) conducted a study with elementary age students and found that when teachers provided such support students supported their claims with evidence, coordinated evidence and theory and challenged each others' perspectives more successfully. Teachers can provide such support and scaffolding only when they have a sophisticated pedagogical knowledge base for teaching science through argumentation (Knight & McNeill, 2011; Kuhn, 2010). When teachers lack such pedagogical content knowledge, argumentation becomes one-directional monologue, where people do not question the validity of claims to knowledge, the authenticity of evidence and the quality of justifications advanced by their teachers and their peers (Erduran et al., 2006). Therefore, we need to identify best practices that can support teachers' acquisition of such pedagogical knowledge and enhance their self-efficacy to teach science through argumentation.

Theoretical Framework: Self-efficacy

We used self-efficacy as a framework to study the effectiveness of our intervention. Self-efficacy refers to teachers' "beliefs about their capacity to perform a task at a specific level of competency" (Bandura, 1997 cited in Goddard, Hoy & Wolfolk, 2000, p. 481). More precisely, he defines self-efficacy as "people's beliefs about their capabilities to produce effects" (Bandura, 1994, p.71). The notion of self-efficacy has significant implications for implementing reform-based ideas in science classrooms. Therefore, a significant number of educators, from various fields, have used the concept of self-efficacy as a theoretical framework to study teachers' knowledge and performance competency in specific domains. Educators' interest in self-efficacy comes from the fact that there is a relationship between people's self-efficacy beliefs and their performance of a specific task. Bandura (1997) states that people's self efficacy beliefs influence how much effort they invest in achieving an objective, how they will persist when faced with challenges, and how they deal with failures and the level of stress they undergo in dealing with demanding conditions. It follows that self- efficacy beliefs affect not only people's thought processes but also their motivations and performance (Bandura, 1989). This implies that teachers' self-efficacy can aid or hinder their implementation of new ideas in their classrooms as it determines the level of effort one may invest in achieving a specific goal and the motivation they hold for completing a specific task.

Studies exploring teachers' beliefs and practices indicate that teachers with a high sense of self-efficacy have more success with achieving their instructional goals than those who lack such efficacy (Ashton & Webb, 1986). For instance, studies show that teachers with a strong sense of efficacy in terms of classroom management and content knowledge are more likely to invest serious professional effort in teaching and creating conditions fruitful to student achievement than those who do not (Loucks-Horsley, Love, Stiles, Mundry & Hewson, 2003). Although science educators highlight the importance of enhancing pre-service science teachers' self-efficacy to teach science through reform-based instructional methods (Poulou, 2007), to the best of our knowledge no previous study has inquired pre-service science teachers' self-efficacy to teach science through argumentation. We aim to address this need by studying pre-service science teachers' self-efficacy to teach science through argumentation. We focus on pre-service science teachers because current research on teacher efficacy suggests that teacher efficacy is most malleable in pre-service years (cf. Housego, 1990; Hoy & Woolfolk, 1990), and tends to be resistant to change with experienced teachers (cf. Anderson, Greene, Loewen, 1988; Ohmart, 1992). This raises the question of: What strategies are more effective at enhancing pre-service science teachers' self-efficacy to teach science through argumentation?

Bandura (1997) states that positive changes in self-efficacy mostly come through "compelling feedback that forcefully disrupts the pre-existing disbelief in one's capabilities" (p. 82). It follows that we need to develop specific instructional strategies consistent with this principle to bring about changes in pre-service science teachers' self-efficacy in relation to their abilities and motivation to teach science through argumentation. In this study, we explored the impact of such an intervention on pre-service science teachers' self-efficacy to teach science through argumentation, and their attitudes and motivation towards teaching science through argumentation.

Research Questions

We explored answers to the following research questions in this study:

1. How does explicit instruction on argumentation-based pedagogy impact pre-service physics teachers' self-efficacy to teach science through argumentation?
2. What are the perceived advantages of teaching science through argumentation?
3. What are the perceived disadvantages of teaching science through argumentation?

METHODOLOGY

Participants

The participants were drawn from an established physics teacher education program in Turkey. The participants consist of 24 pre-service physics teachers (10 males and 14 females), recruited from the same cohort of the program. The participants' age range from 20 to 22 years.

Context

The physics teacher education programs in Turkey are structured based on a structure similar to the Holmes model. According to this model, pre-service science teachers must take a sequence of undergraduate physics and mathematics courses for three and a half years. The students then spend one and a half year taking pedagogy courses and completing their practicum experiences in local schools. While students develop their subject matter knowledge during the first phase of their education, they are guided to develop their general pedagogical knowledge and pedagogical content knowledge through education courses. In addition, they gain classroom-teaching experience through the internship component of their program.

The study took place in a science methods course (i.e. Instructional Methods in Physics) that has a practicum component. This is one of the main courses in the second phase of the program, where pre-service science teachers meet for four hours a week. The course instructor, who is also the first author of the study, taught the course. She designs and implements her lessons based on a constructivist view of learning. The course is designed: 1) to expose the pre-service teachers to the fundamental learning and teaching theories related to physics education in K-12 settings through readings and explicit teaching, 2) to challenge them to design lesson plans based on a constructivist philosophy (especially social constructivism) and implement them in their practicum classrooms, 3) to challenge them to examine their own teaching practices through reflective learning activities, and 4) to have them observe and examine their peers' teaching.

Intervention

The intervention consisted of several steps. First, the participants were asked to define argumentation prior to the intervention. After the participants shared their understanding of argumentation with the course professor, the course professor exposed them to various models and definitions of argumentation and explained the theoretical foundations of argumentation. The course professor specifically explained the consistency between argumentation and social constructivism, and the potential role that the argumentation can play in bringing about conceptual change in students' learning of science concepts. In addition, the course professor made various components of the argumentation models explicit to the participants through examples. The course professor also explained how the roles of the teacher and the students change during argumentation-based teaching. After the professor explained the theoretical foundations of argumentation, described various forms of arguments and provided justifications for its use in science teaching to the participants, she modeled argumentation to the participants through examples.

Specifically, the course professor showed a video of wing-suit athletes. Then, she engaged them in argumentation around four problems related to the topic of dynamics. The first problem was related to the initial velocity of the athletes. The participants' arguments focused on the question of "Does starting with an initial velocity help the sportsmen fly faster?" The second problem was about the forces exerted on the sportsmen during their movements. The participants argued over whether the net force was constant or not. The participants also argued about how the athletes could determine their directions and how they could get on the ground. After the participants discussed solutions of these four problems presented to them, the course professor engaged them in a whole class argumentation for each problem. This process of modeling and mastery experiences lasted for four hours of instruction spread over a week.

One week after the course professor had modeled argumentation with the participants, she challenged them to engage in argumentation by using concept cartoons related to the topic of electromagnetic waves. This argumentation took place in a structured whole class discussion format where they wrote their ideas and reasoning in their worksheets. The participants also engaged in a whole class argumentation related to the matching theories of optics. The participants completed this argumentation sessions in groups of three.

In addition to engaging in verbal argumentation, the participants were also asked to develop written arguments. After the course professor explained the components of Toulmin's (1958) argumentation framework, she distributed the letters including the communications between Newton and Hook about their arguments of physics to the participants. She then asked the participants to identify the components (i.e. claim, data, warrant, rebuttal) of each scientist's argument and to assess their plausibility and validity. The participants completed this assignment in groups of three. This final stage of intervention lasted for four hours of instructional time. The whole purpose of these activities was to familiarize the participants with various components of scientific arguments and challenge them to use argumentation in different contexts.

After the initial eight-hour of intensive experience with argumentation, the participants were challenged to engage in argumentation-based learning related to various physics topics for one and a half hour per week for five consecutive weeks. Finally, the participants were asked to design an argumentation-based lesson using the 5E model. The participants were expected to design their lessons to last for 40-minutes.

In sum, the three-stage intervention involved, 1) exposing students to the theory of argumentation through readings and explicit teaching, 2) engaging students in argumentation-based learning, 3) challenging them to design two argumentation-based lessons and 4) have them implement a lesson in an actual classroom setting. Although all of the participants designed a lesson, only nine of them implemented the lesson in their classrooms.

DATA AND DATA ANALYSIS

Data consist of students' responses to the self-efficacy inventory developed by the researchers and students' responses to three open-ended questions. The self-efficacy inventory consists of 30 5-point Likert scale items consisting of three categories: planning, implementation, and evaluation. The items were developed based on the interviews with in-service science teachers who had previously integrated argumentation into their teaching and in consultation with three science teacher educators who had conducted research on argumentation. The open-ended questions explored the pre-service teachers' beliefs about perceived benefits of argumentation-based pedagogy, perceived disadvantages of using argumentation-based pedagogy in science classrooms and their attitudes towards the use of argumentation in their future classrooms. Both instruments were administered after the participants had completed learning activities related to the intervention.

We used Cronbach's α (alpha) to test the reliability of the scale we developed. The reliability analysis resulted in an α value of 0.742 for the overall scale. According to survey design experts, any values above 0.7 is considered to be a good indication of reliability. We did not conduct any factor analysis because conducting any meaningful factor analysis requires at least 300 cases (Field, 2005). Achieving this number was not feasible in the context of this study because of low course enrolment.

Data Analyses

We used both quantitative and qualitative data analyses methods in this study.

Quantitative Data Analysis. The quantitative data analysis focused on participants' responses to the argumentation self-efficacy questionnaire. We gave each participant a composite self-efficacy score based on their responses to the questions. This analysis resulted in three teacher profiles: naïve, developing and expert. In an effort to become more precise in our profiling of the participants, we categorized them in the planning for argumentation, implementing argumentation and evaluating student learning during an argumentation lesson categories. We considered those who scored at 50% or below in each category as naïve, those who scored between 51% and 75% as developing and those who scored between 76% and 100% as experts (see Table 1 for details). This profiling is important because it enables us to identify pre-service science teachers' learning needs and abilities to related to planning, implementation and assessment in argumentation.

Qualitative Data Analysis. Our qualitative analyses consisted of several stages. First, we read participants' responses to all three open-ended questions and categorized the participants into two groups: those that value argumentation-based pedagogy and those that disfavour argumentation-based pedagogy. Second, we used content analysis approach to analyze participants' responses to the open-ended questions. In our analyses we tried to identify the justifications that the participants provided for their responses (i.e., factoring or disfavouring argumentation). We were able to come up with 14 different justifications stated by the participants favouring the use of argumentation. We reported the frequencies of these justifications. Similarly, we identified 12 different perceived disadvantages to using argumentation in a science classroom. We reported the frequencies of these perceived disadvantages as well. Finally, we analyzed students' responses to the final question that asked the participants to state whether they planned to teach science through argumentation or not along with reasons for decisions. Our analysis resulted in five reasons that motivated the participants to use argumentation in their future classrooms and two reasons for not being motivated to teach science through argumentation. We reported the frequency of each occurrence in participants' responses.

FINDINGS

We report the findings in the following order. We report the results of our quantitative analysis followed by the results of our qualitative analysis. In our reporting, we support our categorization and assertions with actual quotes from participants' responses.

Results of Quantitative Analysis

The aimed determine each participant's level of sophistication (i.e., naïve, developing or expert) in terms of their self-efficacy to teach science through argumentation in the categories of planning, implementation and assessment. For planning, 4.2% of the participants (n=1) fell under the naive category, 25% of the participants (n=6) fell under the developing category and 70.8% (n=17) fell under the expert category. For self-efficacy to implement an argumentation-based lesson, 50% of the participants (n=12) fell under the developing category, and 50% (n=12) at the expert level with no one falling under the naïve category. In terms of their perceived efficacy to assess student learning in an argumentation-based lesson, 67% (n=16) of the participants fell under the developing category and 33% (n=8) of the participants fell under the expert category. In terms of their overall performance on the self-efficacy scale, 58.3% of the participants (n=14) fell under the developing category, and 41.7% of the participants (n=10) fell under the expert category. These results are peresented in table 1.

Table 1. Participants' efficacy profiles.

Category	Planning	Implementation	Assessment	Overall	Scoring Points
Naive	1	0	0	0	0-%50
Developing	6	12	16	14	51%-75%
Expert	17	12	8	10	76%-100%

Table 2. Participants' justifications for the use of argumentation in the classroom.

Justification statement.	Frequency
Argumentation provides a threat-free environment for students to externalize their cognitive skills.	12
Argumentation can help the learners to brainstorm together, to listen to unfamiliar ideas and thus to learn collaboratively.	18
Argumentation provides a context for students to freely express and defend their ideas. This is especially good for students who are shy and often afraid of sharing their understandings with the teacher.	5
Argumentation can help students to develop ability to use data in their explanations more effectively.	5
Argumentation creates a context where high achieving students can make a significant contribution to the learning of low-achieving students.	8
Argumentative discourse encourages the diversity of ideas to come fore and thus helps students to learn from their peers.	13
Argumentation increases students' confidence in their own knowledge.	11
Argumentation encourages inquiry-based learning as it forces students to substantiate the justification of their knowledge.	14
Argumentation encourages students' curiosity for further exploration of ideas. Argumentation causes students to explore ideas in-depth.	12
Argumentation makes learners' initial ideas visible to the learner, and through peer feedback, and ongoing discussion helps students to construct ideas that can withstand the test of rationality and plausibility.	17
Argumentation ensures the participation and contribution of all students.	12
Argumentation contributes to the durability of understandings developed by the students.	9
Argumentation forces students to justify their understanding and persuade others of the validity of their claims, causing learners to develop a deeper understanding.	19
Argumentation can help students develop higher-order thinking skills.	10

These results show that the participants ranked themselves relatively high in terms of their efficacy to plan and implement an argumentation-based lesson and assess students learning during an argumentation lesson. However, participants ranked themselves relatively lower in the assessment category in comparison to the planning and implementation categories. These results suggest that the sequential intervention used in this study improved participants' self-efficacy to teach science through argumentation.

Results of Qualitative Analysis

We asked the participants three open-ended questions. The first question (Q1) asked the participants to report the perceived advantages of using argumentation-based pedagogy in science classrooms. The second question (Q2) asked the participants to report on the perceived disadvantages of using argumentation-based pedagogy in science classrooms. The third question (Q3) asked the participants to indicate whether they will use argumentation-based pedagogy in their instruction or not after evaluating the advantages and disadvantages of argumentation in a science classroom. Students' responses to these questions served as the basis of our qualitative analysis. The results of our analyses are reported next.

Perceived Advantages of Argumentation. All participants but two believed that argumentation created unique learning opportunities for students and provided benefits for their learning. Those who favoured the use of argumentation stated several reasons for its use in the classroom. The details of participants' responses are summarized in Table 2.

These results demonstrate that most participants agreed that argumentation created a unique context for the learners to engage in knowledge construction and evaluation at a higher level of cognition. They believed that argumentation resulted in improved student curiosity, a better understanding of the phenomena under investigation, an in-depth exploration of ideas and increased student confidence in his/her knowledge.

Although exploring the justifications that pre-service science teachers provide for the use of argumentation in a science classroom is important, it is equally important to explore their views of the perceived disadvantages of the use of argumentation in a science classroom. Becoming aware of these perceived disadvantages may

Table 3. Justification provided for disadvantages of using argumentation

Justification Statement	Frequency
Argumentation causes the loss of significant instructional time.	6
It is true that argumentation causes students to think a lot, but when students do not get the right answer at the end of argumentation their minds are very confused. This causes a lot of misconceptions among students.	7
If the teacher does not have pedagogical knowledge and skills for teaching science through argumentation it can put the shy students at a disadvantage.	6
The attention span of some students may not be good enough to follow all of the conversations taking place during argumentations. Thus, frequent use of argumentation can decrease student motivation for learning.	8
If equal and effective participation is not achieved, it can place some students in a disadvantaged position.	5
Argumentation can be bad for students who come into the learning environment with limited or no prior knowledge. The students who lack prior knowledge may not be able to come up with a claim that needs to be substantiated. If the student cannot participate due to the lack of prior knowledge or knowledge of the concepts under investigation, argumentation can be a waste of time for them. A more direct learning strategy may be more beneficial for them.	2
Argumentation will not benefit students if the teacher does not provide the necessary scaffolding. The students may end up leaving the discussion with misconceptions. In order for argumentation to be effective the process needs to be managed very well.	17
One of the disadvantages of argumentation is that you simply do not have time to do argumentation with everything you teach due to time limitations.	5
It can be hard to come up with guiding questions to facilitate argumentation for every topic. Similarly, in order for argumentation to be an effective learning tool students should have developed knowledge of essential concepts.	2
If the teacher does not close the lesson it can cause spread of misconceptions, especially among low-achieving students. .	8
I think that argumentation is a total waste of time. Why spend 40-45 minutes teaching something that you can teach in a 5-10 minute lecture?	1
Argumentation can cause classroom management problems.	3

help teacher educators to design better interventions (especially in their methods courses) that will empower them with adequate understandings, knowledge and skills to successfully implement argumentation in their classrooms. We report the perceived disadvantages of argumentation-based teaching next.

Disadvantages of using Argumentation in a Science Classroom. The second open-ended question asked the participants to report on the perceived disadvantages of using argumentation-based pedagogy in a science classroom. The participants listed many disadvantages related to the use of argumentation-based pedagogy in a science classroom. We report these disadvantages in Table 3.

The participants stated that argumentation could result in misconceptions among the students, it can result in inequities in learning opportunities for some students if the instructional activities are not managed properly, especially for those who tend to be shy, the, time needed to plan for argumentation-based teaching and the perceived negative impact it could have on classroom management. Although all participants conveyed one or two disadvantages of using argumentation in the classroom, two participants particularly did not value argumentation in science classrooms. However, it is important to note that the majority of participants valued argumentation as a means to enhance the quality of their students' learning in science.

Motivation to Teach Science through Argumentation. We also explored the participants' motivations to teach science through argumentation. The results show that all but two participants had motivations to teach science through argumentation. Participants provided several reasons to justify their motivations to teach science through argumentation. The summary of these reasons is listed in Table 4.

Although the majority of participants (n=21) explicitly stated that they planned to use argumentation in their instruction, a significant number of them (n=14) did not think they would use argumentation to teach every topic in their curriculum. For instance, one such participant said:

I do not think I will use argumentation for every topic I teach but I will use it as I see its appropriateness for the topic I am teaching. For instance, I will definitely use argumentation to facilitate my students' learning of the topic of "the nature of physics". However, there is no way that I can teach the topic of Atoms and Quarks through argumentation. These topics are very abstract in nature and it would not be a smart thing to teach them through argumentation. Instead, I will use demonstrations and modelling when teaching these topics.

Others expressed similar perspectives on the use of argumentation in their future classrooms. For instance, another participant said:

Let's face it, using the same method of instruction can bore students. Although I see how argumentation can benefit my students. I do not want to bore them by using the same method of instruction everyday. You need to diversify your instructional methods to keep your students engaged in the material you are teaching.

These results indicate that participants consistently maintained that one could not teach every science topic in their curriculum through argumentation. One theme that consistently emerged in participants' responses was that they did not think that the students could learn science on their own. They stated that science topics are too difficult for young learners to understand on their own. As a result of this understanding, they expressed tendency to control the construction of knowledge in the classroom in the most efficient way possible (i.e. through direct instruction). For instance, the majority of participants (n=19) said that they would not use argumentation very frequently because it hindered their

Table 4. Motivation to Teach Science through Argumentation

Statement	Frequency
I will use argumentation especially for the purpose of identifying students' misconceptions.	21
I will use argumentation because it makes learning science enjoyable.	4
I will use argumentation because it results in acquisition of social interaction skills.	12
I will use argumentation because it makes learning accessible to all students as it forces all students to think and share ideas.	3
I will use argumentation because it encourages students to explore scientific ideas in-depth.	8

Table 5. Reasons for lack of motivation to teach science through argumentation

Statement	Frequency
I think argumentation is not useful. It takes a lot of time to implement it in the classroom. Instead of spending time in having students argue, I can go over the details of the topic with the students, have them review the material and make connections with real life applications of the concepts covered during the instruction.	2
I do not think I will use argumentation. Instead, I will prefer to have discussions that result in a definite response. When you use argumentation students get confused, which can result in many misconceptions.	2

ability to cover the mandated curriculum. A second justification that the participants used for not planning to use argumentation very frequently in their future classrooms was the perception that using the same method of instruction could bore students and thus decrease their motivation to learn science.

The two participants that consistently expressed negative views towards the use of argumentation in the classroom provided reasons that are similar to the two exemplary statements given in Table 5.

A close look at these responses indicates that these participants held a negative view towards argumentation because they believed argumentation did not result in a definite answer. They argued that the ambiguity caused by argumentation would confuse students and not help them learn science. Second, they thought that the time spent on argumentation could be spent on exposing students to the details of the topic under investigation, and thus bring about better learning outcomes for students.

Summary of Findings

The findings reported so far indicate that the intervention used in this study proved to be an effective method of instruction for increasing pre-service science teachers' self-efficacy to teach science through argumentation. The results showed that pre-service science teachers who participated in this study: 1) held positive attitudes towards the use of argumentation for engaging their students in meaningful science learning, 2) reported high-self-efficacy to teach science through argumentation and 3) indicated high motivation to teach science through argumentation in their future classrooms and 4) provided various justifications for their motivations to teach science through argumentation. Although the participants mostly favoured the use of argumentation, they shared their hesitations for teaching science through argumentation as well. We elaborate on the implications of these findings for science teacher education, future research on argumentation and the teaching of argumentation in K-12 settings in the next section.

DISCUSSION

Results of our study indicate that the pre-service science teachers who participated in this study showed different degrees of self-efficacy to teach science through argumentation. While the participants' self-efficacy to plan for and teach science through argumentation was higher than their self-efficacy to assess students' learning during argumentation, they shared some concerns regarding the actual implementation of argumentation-based pedagogy. This is expected given that teacher efficacy is dependent on several factors: teachers' knowledge of science content, the complexity of the task to be performed and the context in which the task is being performed (Goddard, Hoy & Woolfolk, 2000).

Enhancing science teachers' self-efficacy to teach science through argumentation is critically important, especially in this era of increasing emphasis on high-stakes testing that encourages teachers to teach science through traditional instructional methods (i.e., lectures). When pre-service science teachers have high self-efficacy to teach science argumentation, they are more likely to use argumentation once they become classroom teachers. If pre-service science teachers lack self-efficacy to teach science through argumentation, they are more likely to teach science through direct instruction.

Previous studies reveal that pre-service teachers' beliefs are more malleable than those of more experienced teachers (So & Watkins, 2005). It has been argued that pre-service teachers' beliefs are more malleable because they have fewer mastery experiences to reflect on than those with years of experience. This limited mastery experience may have a negative influence on their self-efficacy because there are few cases that they can draw from (Bandura, 1997). Although we did not compare the efficacy beliefs of pre-service teachers with those of experienced teachers, we observed that the intervention used in this study enhanced the pre-service science teachers' self-efficacy to teach science through argumentation. This result is encouraging in that other science teacher educators can use similar interventions to enhance their students' self-efficacy to teach science through argumentation. However, we caution our readers to recognize that this perceived self-efficacy may not result in actual teaching of argumentation in the classroom. This is because curriculum mandates, the types of students taught and school culture can have a significant impact on the type of instruction that teachers implement in their classrooms. In addition, lack of measures that hold teachers accountable for the use of reform-based instructional practices such as argumentation can also have a negative impact on teachers' motivation to teach science through argumentation. Therefore, it is likely that some of these teachers will not teach science through argumentation consistently. Given the emphasis placed on students' readiness for the nationwide university entrance examination and parents' expectations for increased test scores, it is likely that some or most of these teachers will use traditional methods of instruction that have proven to raise students' test scores. It follows follow up studies that can track whether these teachers will continue to use argumentation in their instruction or not are necessary. The results of such studies can help science teacher educators develop an understanding of the challenges and successes experienced by these teachers. Such an understanding can help science teacher educators to find support structured for in-service teachers so they can use reform-based instructional strategies such as argumentation more effectively.

Knight and McNeill (2011) developed a professional development program to enhance practicing elementary and secondary science teachers' pedagogical knowledge to teach science through argumentation. The results of their work showed that while teachers made significant gains in terms of valuing the role of evidence in student writing and promoting students' reasoning skills, the application of such knowledge in their practice was still a challenge for majority of the participants. In their conclusions, they stated that in order for teachers to use argumentation effectively, they needed more support in the context of their teaching and more practice with designing and implementing argumentation-based learning activities. One place where we can start to think about addressing science teachers' learning needs to teach science through argumentation is science methods courses. However, before science teacher educators can begin to design and provide meaningful learning experiences for pre-service science teachers, they must convince teachers about the value of scientific argumentation in the classroom and increase their motivation to teach science through argumentation (Sampson, 2009).

By focusing our efforts on pre-service science teachers, we can identify their misconceptions related to argumentation-based pedagogy and weaknesses in their self-efficacy to teach science through argumentation. Once we have identified their misconceptions and weaknesses we can design effective instruction to address their needs before they enter into the classroom. However, we argue that it would be naïve of us to expect that all of the pre-service science teachers who have self-efficacy to teach science through argumentation will actually use argumentation once they become teachers.

Studies show that teachers draw from many sources of knowledge when making decisions related to instruction and assessment (Author, 2007; Avraamidou & Zembal-Saul, 2005; Crawford, 2007). The understandings, knowledge and skills that they acquire in pre-service years are only one source from which they can draw their decisions from but not the only one. Factors such as district policies, school culture, the student population served and peer influences also impact the instructional decisions made by a teacher (Osborne et al., 2010). Sampson (2009) found that the majority of teachers he studied cited: 1) their students' limited abilities to learn through argumentation, 2) the issues of time to cover mandated curriculum, 3) their lack of knowledge of argumentation-based pedagogy and 4) the limited resources available to them for teaching science through argumentation as the justifications for not using argumentation in their teaching. Consistent with this conclusion, we believe that future research efforts must also focus on the factors that may aid or hinder a teacher's ability and motivation to teach science through argumentation in the classroom.

LIMITATIONS

As it is true of any educational studies there are several limitations to this study. First, we conducted this study with 24 pre-service physics teachers only and in Turkey. Therefore, these results are limited to the participants and the context within which this research was conducted. Second, the argumentation topics used during the intervention might have had an influence on participants' reported high self-efficacy. The same may not be true for other science topics. While our results are encouraging, more research needs to be conducted with a diverse group of pre-service science teachers and in diverse science contexts before these results can be generalizable to the population from which we draw our sample.

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