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A Case Study of Preservice Science Teachers with Different Argumentation Understandings: Their Views and Practices of Using Representations in Argumentation

Bahadir Namdar[i]
Recep Tayyip Erdogan University,

Abstract

Representations are fundamental tools to support argumentation in science learning. However, little is known about how preservice science teachers (PSTs) with different argumentation understandings view and use representations in argumentation. Therefore, the purpose of this case study was to explore the views and practices of PSTs' use of representations for argumentation purposes. The participants were six graduate students enrolled in an argumentation course in a northeastern university in Turkey. Data was collected through videotaped lessons, the PSTs' artifacts and semi-structured interviews. Video analysis and content analysis were used to investigate research questions. Results indicated that with the increased argumentation understandings the PSTs showed a sophisticated understanding of using representations for argumentation. Moreover, with the increased argumentation understanding the PSTs used representations for multiple purposes during argumentation and used visual-graphical representations as rebuttals and counterarguments. Implications include the explicit teaching of the purpose of multiple representations in argumentation, integration of representational and argumentation practices in teacher education programs, and enriching argumentation experiences by providing learners with multiple representations.

Keywords: science education; argumentation; multiple representations

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Bahadir Namdar[i] Assist. Prof. Dr., Department Of Mathematics And Science Education, Faculty Of Education, Recep Tayyip Erdogan University, Rize, Turkey

Correspondence: bahanamdar@gmail.com

Introduction

In an effort to make learning more meaningful, research and practice in school science education has long been concerned with engaging students in similar contexts and authentic practices of scientists (Bricker & Bell, 2008). Argumentation, one of the core epistemic practices in science, has received an increasing amount of attention from science education research community (Lin, Lin, & Tsai, 2013). It has been widely used as an instructional approach (Osborne, Erduran, & Simon, 2004; Sampson, Grooms, & Walker, 2011) and found to be an effective tool to enhance students' conceptual understanding (Aydeniz & Dogan, 2016; Eryaman & Genc, 2010; Zohar & Nemet, 2002), nature of science understanding (Bell & Linn, 2000; Yerrick, 2000) and problem solving (Cho & Jonassen, 2002). Not surprisingly it has become an important component of science curricula across the globe for the last decade (Australian Curriculum, Assessment and Reporting Authority, 2012; Milli Eğitim Bakanlığı, 2013; NGSS Leads States, 2013).

Development of science and scientific knowledge can be characterized as the advancement and the use of multimodal discourse (Oliveira, Justi, & Mendonça, 2015). Using representations (often in different modalities such as in text, graphs, diagrams and models) scientists propose their claims, justify their ideas and share their findings. Suggested by both empirical and theoretical research, using more than one representation (i.e. multiple representations) have potential to support discourse and argumentation (Ainsworth, 1999; Kozma, 2003; Pallant & Lee, 2015). Recent empirical research in science education also suggest that argumentation leads further use of representations for organizing knowledge in argumentation contexts (Namdar, 2015; Namdar & Shen, 2016). However, most studies neglect the influence of learners' scientific argumentation understandings when they utilize representations for argumentation. Hence, the purpose of this study was to explore preservice teachers' (PSTs) views of using representations for argumentation when they hold different argumentation understandings. Research questions investigated in this inquiry are: (a) What do PSTs know about argumentation? (b) What are PSTs' views of using representation in argumentation? c) How do PSTs use representations in their socioscientific arguments about alternative energy?

Theoretical Perspectives

Argumentation

In a broad definition "an argument consists of either assertions or conclusions and of their justifications, or of reasons or supports" (Zohar & Nemet, 2002, p. 38). According to Toulmin's (1958) model of argumentation components *claims* are assertions, conclusions, hypothesis or beliefs; *data* are evidence that supports a claim; *warrants* are links between data and a relevant claim; *qualifiers* indicate the strength of warrants to a claim; *backings* refer to underlying assumptions which strengthen the acceptability of a claim or justify the warrants; and *rebuttals* are statements that contradict other presented evidence. Argumentation, on the other hand, is creating arguments, which can enable arguers to use scientific data and evidence while proposing claims or opposing counterarguments (Simon, Erduran, & Osborne, 2006).

Argumentation gives students ample opportunities to extend their knowledge, communicate their ideas and remediate their misconceptions (Newton, Driver, & Osborne, 1999). However, researchers indicate that argumentation opportunities are still missing in science classrooms (Osborne, 2010). Therefore, incorporation of socioscientific issues in science education curricula has been advocated. Socioscientific issues are complex, controversial and ill structured problems with ties to science and society (Sadler, 2004). These issues involve diverse social, economic, ethical, ecological and political perspectives. Therefore, there are no clear-cut solutions (Zohar & Nemet, 2002).

Making well-informed decisions about socioscientific issues require individuals to use reasoning strategies. However, reasoning strategies differ in scientific and socioscientific contexts. Scientific problems, which are well structured, require arguers to use formal reasoning that is ruled by logic and mathematics (Sadler, 2004). The premises reached at the end are fixed and away from personal ideas (Evans & Thompson, 2004). On the contrary, arguing on socioscientific issues require arguers to use informal reasoning as the premises reached are subject to be changed with additional data and evidence (Kuhn, 1991; Means & Voss, 1996). Today's democratic societies increasingly require their citizens to employ informal reasoning skills to formulate positions and argue about these planetary issues (Sadler, 2004). Therefore, in this study the participants were provided with a socioscientific issue of energy as the context of the study.

Argumentation in Science Teacher Education

Argumentation has been widely studied in terms of student learning. Empirical results indicated that argumentation increase learners' conceptual science understanding (Bell & Linn, 2000; Yeşildağ-Hasançebi & Günel, 2013), attitudes towards science (Günel, Memiş, & Büyükkasap, 2010) and nature of science understandings (Bell & Linn, 2000; Yerrick, 2000). Although given the known benefits and its place in school science curricula, researchers indicate that science teachers still lack pedagogical skills to incorporate argumentation in their classrooms (Driver, Newton, & Osborne, 2000; Simon et al., 2006). Teachers are more likely to incorporate this core practice in their classroom when they had prior experiences (Zohar, 2008). Therefore, it becomes an important agenda in science teacher education programs to incorporate argumentation-based pedagogical learning and teaching experiences for teachers of the future (Kaya, 2013).

P PSTs' argumentation has been a growing research interest in science education. Recent studies investigated the effect of argumentation practices on PST's conceptual science understanding (e.g. Cetin, Erduran, & Kaya, 2010; Ozdem, Ertepinar, Cakiroglu, & Erduran, 2011), self-efficacy (e.g. Ogan-Bekiroğlu & Aydeniz, 2013), the relationship between PST's epistemic belief levels and argumentation qualities (e.g. Isbilir, Cakiroglu, & Ertepinar, 2014), and PST's teaching strategies of argumentation (e.g. Erduran, Ardac, & Yakmaci-Guzel, 2006).

Although there are new curriculum initiatives, technology environments and instructional strategies, a skilled teachers who understand scientific knowledge is still need to successfully implement argumentation innovations (Sampson & Blanchard, 2012). Therefore, it becomes important to have well-informed teachers who value argumentation as well as the argumentation structure. Investigating 30 inservice secondary science teachers' evaluation of alternative explanations, generation of arguments to support explanations and views about using argumentation as part of the teaching and learning of science, Sampson and Blanchard (2012) found that the teachers failed to provide a support for an explanation and used prior knowledge to validate their arguments rather than using available data. Teachers also held views about integration of argumentation based on students' ability levels. However, it is evident from the literature that limited number of studies investigate PSTs' understandings of argumentation. However, PST's argumentation understandings remain as a relatively unexplored area. However, there still little studies exist investigating PSTs' argumentation understandings, whom will be the effective mediums for future change in the classrooms (American Association for the Advancement of Science, 1993; Aydeniz & Dogan, 2016). A recent study on PSTs' views on argumentation Aydeniz and Ozdilek (2015)investigated 40 preservice elementary science teachers' views on argumentation. Results indicated that the PSTs lacked proper understanding of scientific argumentation.

Representations in Argumentation

Representations refer to a "range of transformations that conceptualize, visualize, or materialize an entity into another format or mode" (Wu & Puntambekar, 2012, p. 755). According to Wu and Puntambekar (2012) representations can be classified in four categories: verbal-textual (metaphors, oral propositions and written text), symbolic-mathematical (equations, formulas, structures), visual-graphical (animations, simulations, diagrams, graphs, tables), and actional-operational (demonstrations, gestures, manipulatives, physical models).

Scientists use multiple representations (e.g., tables, graphs, models, simulations, formulas) in their inquiry to construct their individual understanding, communicate their ideas and advance science. Therefore, science as an enterprise develops as a multimodal discourse through (multiple and multimodal) representations (Kozma, 2003). In other words, scientists intersect argumentation and representational practices to generate knowledge. Recently, studies in science education also highlight this important relationship. According to Ainsworth (Ainsworth, 1999, 2006) there are three key functions of using multiple representations: (a) complementary functions: different representations includes different information and they complement each other; (b) constraining functions: certain combinations can help learning when one representation constraints interpretation of a second representation, (c) constructing functions: multiple representations support the construction of deeper understanding. Research indicates that learners use multiple representations as evidence to support their arguments (e.g. Namdar & Shen, 2016; Pallant & Lee, 2014) and recite their claims and reflect on their ideas (e.g. Hand & Choi, 2010). Furthermore, through argumentation and discourse, learners revise representations (e.g. Namdar & Shen, 2016; Hogan & Thomas, 2001).

In recent years, the advent of information communication technologies changed the ways people work, communicate and even argue about local and global issues that the world face. In today's information era, citizens of democratic societies are exposed to immense data, evidence and ideas about socioscientific issues. This demands learners to search, cluster, and organize knowledge to make sound arguments (Namdar & Shen, 2016). As data about these complex issues are in multiple format and modalities; learners need to know how to use them effectively to communicate their ideas and construct well-informed arguments. In PST education particularly, this is more demanding as college years are critical for the teachers of future as they could potentially bring those pedagogical experiences in their future classrooms (American Association for the Advancement of Science, 1993). However, still little is known about how PSTs perceive the use of representations in argumentation.

Method

General Background of Research and Participants

This study was conducted in a mid-sized public university in northeastern Turkey in 2015-2016 fall semester. There were only eight PSTs who enrolled in a graduate level argumentation course and six PSTs (three male and three female, pseudonyms are used, names starting with M presents male, with F presents female students) consented to participate in the study, completed all the assignments, and participated in the final interview. Although the six participants already completed their undergraduate middle school science education program and enrolled in a master's program in science education, the participants were identified as pre-service teachers in this paper for two reasons. First, these participants were neither appointed to work as science teachers by the ministry of education nor had a formal teaching experience at private or public schools. Second, at the beginning of the course, all participants indicated being an appointed science teacher as their primary career goals in an online course survey. The participants completed courses in all areas of science and pedagogy during their undergraduate programs. The participants' ages ranged between 23-26. The author of this study was the course instructor and necessary permission were obtained from the college to conduct the study.

Procedures

The argumentation course met once a week for three hours over 14 weeks during a fall semester. Before the implementation of this study the participants were introduced to argumentation theory including rhetorical and dialogical argumentation, decision making and socioscientific issues topics. In the current study, the PSTs were given an article about the hydroelectric power plant construction where this study took place. The article states the number of hydroelectric power plant construction in the city as well as positive economic and negative environmental impacts of hydroelectric power plants. This topic was chosen because there is still an ongoing debate about the issue, especially with the increased numbers of hydroelectric power plant construction where this study took place. The PSTs were asked which energy type we should rely on as an alternative energy source. Choosing one alternative energy type, each participant was asked to collect data in multiple formats such as in graphs, tables and texts and then prepare a research brief. The research briefs had to include at least 10 resources. On each single page, the participants had to summarize the data and rate how reliable they though the source was. The participants were given 3 weeks to complete this task. The PSTs were asked to prepare a poster reflecting their final argument. Finally, they had 20 minutes to present their posters and 10 minutes to answer their peers' questions in the classroom. At the end of the presentations the participants were involved in a whole class level argumentation where they discussed the issue.

After in class sessions, an hour long individual semi-structured interviews were conducted. The interview included two sections: the PSTs' argumentation understandings and their views of using representations in argumentation. The first part of the questionnaire, the PSTs' argumentation understandings, included three questions, and was adapted from a previous study (Aydeniz & Ozdilek, 2015). The second part of the questionnaire was developed by the author and another science education researcher. Then, two different experts who were faculties in a science education department and had qualitative research experience, evaluated the form. Then, the interviews were conducted with two preservice teachers in an undergraduate science education program to identify the inconsistencies in the form. The final version of the questionnaire included six questions to identify PSTs views of using representations in argumentation (e.g. which representational mode do you think better/worse support argumentation, in the study which representational types do you think better supported your argumentation process and why?). Finally, individual interviews were conducted by the author after the implementation of the study. During audiotaped interviews the participants were given their research briefs and posters and reminded that they can use their briefs and posters to answer any questions.

Data Analysis

In this research, case study approach was used to have in depth understanding of the PSTs' views and practices of using representations in argumentation, when these PSTs hold different argumentation understandings (Yin, 1994). First, all audio and video recordings were transcribed verbatim by a professional company and checked for second time by the author. Then, the first part of the questionnaire was analyzed employing content analysis which was influenced by a previous research that investigated PSTs' argumentation understandings (Aydeniz & Ozdilek, 2015). This part of the questionnaire investigated the PSTs argumentation understandings and included three questions: (a) What is scientific argumentation? (b) What are the core elements of a scientific argumentation? and (c) What is the purpose of scientific argumentation? Each question was assessed as informed (3 points), transitional (2 points) and naïve (1 point) based on open coding (Corbin & Strauss, 2008). Then each PST's total mean score to this part of the interview was calculated. Finally, their argumentation understandings were categorized using same categories. To establish trustworthiness the PSTs' responses were read and assessed independently by two researchers (Gibbs, 2007). After individual coding researchers met and discussed their evaluations until the disagreements were resolved.

Second, the video-records of the PSTs' presentations were analyzed by adopting an analytical model suggested by Powell, Francisco, and Maher (2003). Video data was analyzed following the steps: (a) The video data was viewed attentively, (b) the transcriptions of the video recordings were checked, (c) critical events were identified. Critical events refer to the participants' actions of showing representations in their posters while talking in one turn and noted in the transcripts; (d) coding: Coding was conducted in three stages: Identifying the purpose of using multiple representations, argument components, and representation modalities. *The purpose of using multiple representations* based on Ainsworth's (1999) categorization as mentioned in the theoretical framework were also coded. *Argument components*: each turn was coded based on Toulmin's (1958) argument components model. However, to give condensed view of the results data, warrant and backings were categorized as justifications. A turn consisted of a speech sequence when one person completely presented an idea. On the other hand, each turn's argumentation component was compared with the component of the representations in the posters. In order to give an overview of the posters created by the participants, *types of representations* included in the poster were also identified (Wu & Puntambekar, 2012) and number of representations in each participant's posters was reported.

Third, employing open coding (Corbin & Strauss, 2008) two researchers independently analyzed the PSTs' answers to the questions regarding the PSTs' views of using representations in argumentation. Based on the PSTs' argumentation understandings cases constantly compared to identify similarities and differences (Glaser & Strauss, 1967). Researchers regularly met to discuss their coding and resolved all inconsistencies (Gibbs, 2007).

Results

PSTs' Argumentation Understandings

Based on the participants' answers to the first part of the interview, results indicated that the participants had different levels of argumentation understandings including the structure and the purpose of argumentation. In total, there were two PSTs with naïve, three PSTs with transitional, and one PST with informed argumentation understanding (Table1).

Table 1: *The Participants' Argumentation Understandings*

PST	Argumentation			Structure of argumentation			Purpose of argumentation			Level
	N	T	I	N	T	I	N	T	I	
Mehmet		✓			✓			✓		T
Filiz	✓			✓			✓			N
Fatma		✓				✓		✓		T
Fulya	✓			✓				✓		N
Mert			✓			✓			✓	I
Mustafa		✓			✓			✓		T

N: Naïve T: Transitional I: Informed

PSTs' views about argumentation. First question asked students about their views of argumentation. Filiz and Fulya indicated naïve, Mehmet, Fatma and Mustafa indicated transitional, and Mert showed informed views of argumentation. Those who held naïve views either frame argumentation as a general discussion between multiple individuals with no reference to the importance of scientific evidence or justification or provide non-normative ideas about argumentation. For instance, Filiz indicated that "Scientific argumentation can be changed by collecting more data but eventually we all reach the same argument and conclusions" (Filiz, Interview). Fulya on the other hand, mentioned that argumentation help arguers to convince their audience about the claims that they have. Those with transitional views, on the other hand, focus on the role of scientific evidence and justification but fail to effectively elaborate on the argumentation structure with also no reference to competing claims.

> Argumentation is the process of supporting and proving claims with evidence. It is a type of scientific discourse. For instance, we have a claim and data. It is not a simple discussion but instead argumentation is the stage of supporting it [the claim] with evidence. Hence, argumentation is a process and the argument is a product that has been produced through this process. (Fatma, Interview).

The results indicated that Mert showed informed views of argumentation. Mert focused on the roles of claim and evidence, competing claims regarding defending and justifying claims. He further mentioned the structure of arguments.

PTSs' views about structure of argumentation. The PSTs were asked to identify the core elements of an argument. Filiz and Fulya expressed naïve, Mehmet and Mustafa expressed transitional, and Mert and Fatma expressed informed views about structure of argumentation. The PSTs who had naïve views failed to name the presence of justifications, competing theories, warrants, evidence and rebuttals. For instance, Fulya said that "Let's say I have a claim that I support and I need to prove it. I need to prove my case to my audience" (Fulya, Interview). On the contrary, those with transitional views state the components of arguments but fail to elaborate on them. Mustafa who had transitional understanding said the following:

> Claims are assertions that we put forward about an idea. Data could be in any form, those could be based on observation or research, and these are the data that we collect to support our claims. Again, these could be in the forms of graphs or pictures. For instance, I inserted a table here to support my claim about the cleanliness of solar energy (Figure 2). These could be used as warrants. Because, if the additional data supports our claim and our initial data sources we call them warrants, I guess. Rebuttal is, well there is a thing called counter argument. It is against what we initially claim. Then, to rebut this you use rebuttal and again support your initial claim and support ourselves [claim]. In other words, rebuttal is the statement that rebuts the counterargument, right? (Mustafa, Interview).

Mert showed informed views about the structure of argumentation. Different from the participants' views in other two categories Mert's views included the place of an interlocutor as well as the alternative hypothesis in argumentation Different from naïve and transitional views, the participants with informed understanding fully elaborated on each argumentation component based on the Toulmin's model of argumentation.

PTSs' views about the purpose of argumentation. The PSTs were finally asked to identify the purposes of scientific argumentation. The results indicated that four participants showed transitional understanding. Filiz who had naïve views about the purpose of argumentation failed to capture the purpose of using argumentation as a scientific practice for advancement of knowledge and had no reference to justifying claims.

> …scientific explanation sounds like a distant concept for public. Normally, general public also creates explanations for a given problem. It is embedded in daily life but you need to attribute it to a specific structure or subject and then create arguments. I also believe it is not only useful for making explanations but also exchanging ideas. (Fulya, Interview).

Those holding transitional views emphasized the notion of persuading others by justifying claims and the importance of scientific evidence.

> Argumentation is an effective way to propose your ideas, your claims to whomever you are talking. You might have evidence to support your ideas while talking to the other person because one thing in your mind is to make sure that you support what you say. The more reliable the sources of your data are more solidly you can defend your position. (Mustafa, Interview).

The participants in this category, however, failed to indicate the place of counterarguments and improving validity of a claim. Mert, who had informed view, emphasized the importance of establishing, supporting, refuting or improving the validity of a claim and emphasized the creation of scientific knowledge through using scientific evidence. Mert also indicated the importance of persuading others' using evidence.

PSTs' Views about Using Multiple Representations in Argumentation

PSTs' views about the purpose of using representations in argumentation. The PSTs with naïve argumentation understanding indicated that they used different modalities of representations to draw attention to the arguments they presented. "I did a research in this project and I wanted to present my argument. I did not want to have just textual representations I also wanted to appeal people who have different intelligences. I want to have something more visual". (Fulya, Interview). Fulya's poster included more visual-graphical representations (Figure 1). She said:

> "First, I might have explained my problem statement, I mean my claim [shows the written statement on the right corner of her poster, Figure 1]. My audience could be interested in to see the picture on the top of this poster right below the heading and could be curious to hear about my argument. For example, a student might be interested in to see whether this represents an explosion. In fact, this is a picture showing a water source that comes out of the ground which is heated by the magma and pressured out by the heat [shows the picture again]" (Fulya, Interview).

Fulya further indicated that her "explanation cards" [written cards in the middle of the poster, Figure 1] also drew more attention because those cards were "visually appealing" (Fulya, interview). Interestingly, Filiz who also had naïve argumentation understanding said that utilizing representations in argumentation can help arguers to draw more attention. She said:

> I think representations are used to draw attention to your argument. For instance, my poster includes my argument about relying on solar energy. Here I put a lot of pictures in the middle of my poster and I think those representations were the best to appeal my friends' attention to my argument during our presentation (Filiz, Interview).

Both Filiz and Fulya's interviews indicated that they failed to understand the purpose of using representations for justifying claims. Filiz and Fulya's views of argumentation also failed to recognize the importance of argumentation to justify claims.

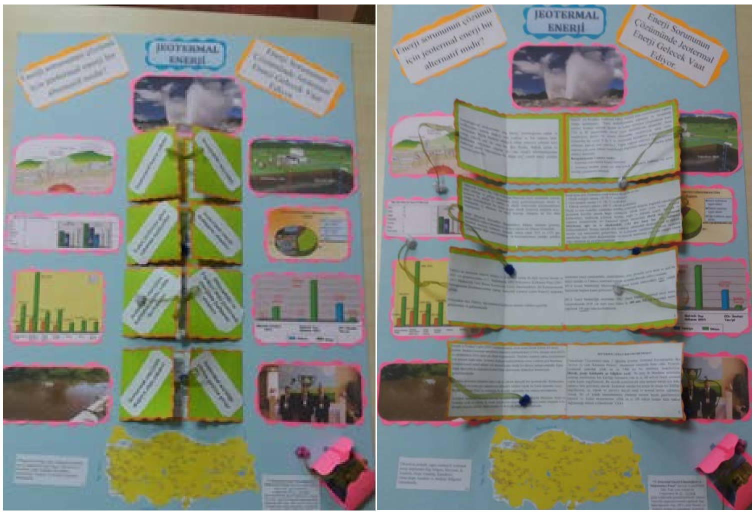

Figure 1. Fulya's poster on geothermal energy

However, the PSTs with transitional and informed argumentation understanding indicated that utilizing representation in argumentation helped them to merge different information sources to build a better justified argument because different representations had different affordances. For example, Mehmet said

> For example, this graphic [shows the pie chart on the bottom right corner that includes information about the energy types, Figure 2] includes information about hydroelectric plants. Next to it I put a picture representing it. Here, I imagine that an interlocutor could make connections and check the reliability of sources. Then they help me to make my overall argument about the hydroelectric power. (Mehmet, Interview).

What separates these answers from the PSTs with naïve argumentation understanding is that these participants explicitly reference justifying claims through scientific evidence. Different from the participants with naïve argumentation understanding these participants also mentioned justifying claims and importance of evidence when they were asked to identify the purpose of argumentation.

PSTs' views about the purpose of using multiple representations in argumentation. The PSTs with naïve argumentation understanding believed that using multiple representations in argumentation helps for knowledge retention.

> Filiz: "Those [multiple representations] help for knowledge to stick for a longer time. What I mean here is that for instance text can reflect my claim but if I, as a teacher for instance, bring a model or a graph to the class that includes information about solar energy this could make the knowledge stay in their mind for a long time. Therefore, in my poster, for example, I put [counting the pictures in the poster] 6 pictures right in the middle of it"
>
> Researcher: How about these text boxes over here?
>
> Filiz: Well again as I said, they all explain what I tried to imply in the pictures. For my audience, it would be hard to forget my claim about the solar energy [laughter].

Although Filiz used a textual representation to help readers to interpret pictorial representations, she failed to identify it. Fulya and Filiz, on the other hand, both mentioned the benefits using multiple representations for presentation purposes. However, these students failed to recognize the roles of multiple representations in terms of knowledge construction through/for argumentation. One thing to note that these participants did not mention the importance of justifying claims as the purpose of argumentation in the first part of the interview.

On the contrary, the participants with transitional understanding mentioned that one representation can help explain another representation.

> These altogether represent more coherent information. For instance, tables summarize graphics, those graphics (Figure 2) in my poster for instance more abstract ideas in it. If I put only a table, it could not be very prone to be explained, I mean, tables, well as you indicated having multiple representations, helps us better explain another representation. At least that's what I did in my poster. This way, I believe I can better support my argument, because I make my evidence easy to understand for the audience and I can easily convince them (Mehmet, interview).

These participants' views of the purpose of argumentation included the importance of evidence to persuade others. The participants with transitional understanding value the place of multiple representations as evidence to support claims to convince others. Mert, who had an informed argumentation understanding, indicated different purposes of using argumentation.

> First, as they have visual diversity using multiple representations in an argument makes it more appealing for the audience. Second, since different data sources can explain different facets of one common phenomenon that is argued, if I have more than one representation I can explain my claim better. On the other hand, one representation can help the other representation to be understood. If we have a table in a text, text could explain what is included in that table. For sure, it could help people with different age levels and

background. Another important aspect of having multiple representations is that they may contain different information and overall you may want to connect those data sources to argue about something. The different information will, well, make your argument or overall representation more appealing, but for the most part it helps you to structure a better argument. That's what I did in my poster (Mert, interview).

Mert focuses on the roles of multiple representations as data to construct a sound argument. He also mentions the constructing functions of multiple representations. His interview indicates that he also views using multiple representations as to enhance the quality of arguments.

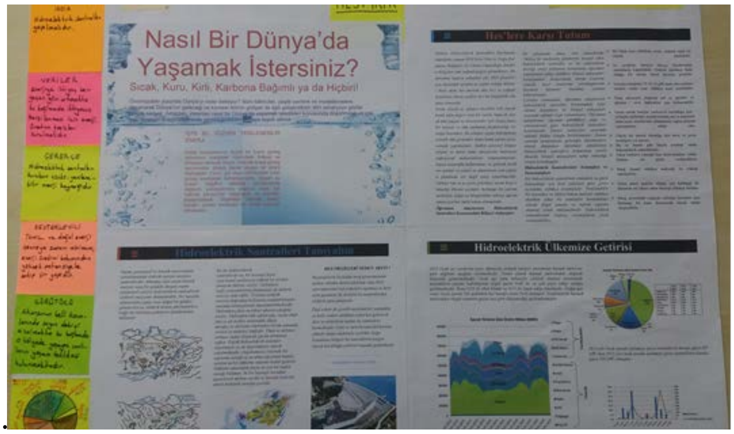

Figure 2. Mehmet's poster on hydroelectric power

PSTs' Use of Representations in Argumentation

Although the interview indicated how the PSTs view the use of representation in argumentation, it does not indicate how the PSTs use representations in an actual argumentation setting. Therefore, utilizing video analysis suggested by Powell et al. (2003) the PSTs' use of representation in argumentation were analyzed. Each participant created a poster reflecting their overall argument about the energy issue. Employing content analysis, it is found that the PSTs' posters included mostly textual representations. On the other hand, among visual-graphical representations they relied on graphs and pictures (Table 2).

Table 2.: *Representation Modalities Used Across the PSTs' Posters*

	Modality	Mehmet	Filiz	Fatma	Fulya	Mert	Mustafa
Verbal-textual	Text	6	11	7	10	9	10
	Equations/Formulas	0	0	0	0	0	0
Visual-graphical	Diagram	3	1	1	2	3	2
	Graph	4	0	1	4	0	2
	Tables	1	1	1	1	0	4
	Models	0	0	0	0	0	0
	Pictures	2	6	5	4	6	13

PST's use of representational modalities for argumentation. Video analysis indicated that the PSTs used textual representations when they initially presented their claims to their peers. All participants who started to present their claims directly read their claims from their posters.

Here I put my research question: Should we rely on solar energy? My claim, which I wrote here [shows the writing at top of the poster is] "Yes, we should make the solar energy use more common. And now I will explain why we exactly need to do that" (Mustafa, poster presentation)

The participants who had naïve argumentation understandings failed to use visual representational modalities to rebut or counterargue their points. These participants used textual and visual graphical representations to justify their claims. Different from the participants with naïve argumentation understandings, the participants holding transitional views used diagrams, graphs and tables as rebuttals.

Mehmet: Well, I think we should build hydroelectric power plants. Now, let me explain why I think this way. First, in my poster I put this graph which compares the energy production levels of each energy types [shows the graphic at the bottom center]. Let's see the other energy types used in Turkey. You see recent numbers for 2015 here. Filiz talked about the wind power and said it is very clean but it is as you can see here only 5.7 % but it is not enough for the country's energy need but hydroelectric power plants produce 35% of the energy need (Points to the graph, Counterargument).

Fulya: But the construction cost is very high.

Mehmet: Yes, it is. It is a disadvantage. There needs to be magnificent investments. One can say that the construction cost is high but it can be neglected because in return it provides a source for you for the next 30-40 years (rebuttal). This can be tolerated because Turkey as a land raised in the fourth geological area completely and therefore it increased the water flow regime. Therefore, our potential [for hydroelectric power] is very high (counterargument). (Mehmet poster presentation, video recording)

Mert, who had informed argumentation understanding, used both representational modalities to justify their claims. Furthermore, he used pictures and texts and synthesized counterarguments using pictures embedded in his poster.

Table 3.: The Number of Turns Different Representational Modalities were Used to Support Argumentation Components

	Modality	Mehmet	Filiz	Fatma	Fulya	Mert	Mustafa
Claim	Text	1	1	1	1	1	1
	Diagram	0	0	0	0	0	0
	Graph	0	0	0	0	0	0
	Table	0	0	0	0	0	0
	Picture	0	0	0	0	0	0
Justification	Text	8	9	3	8	7	6
	Diagram	3	1	1	3	2	0
	Graph	2	0	0	2	0	1
	Table	3	3	1	1	0	0
	Picture	1	2	1	2	2	1
Rebuttal	Text	1	0	2	0	3	2
	Diagram	0	0	0	0	2	0
	Graph	1	0	1	0	0	0
	Table	2	0	0	0	0	2
	Picture	1	0	2	0	1	0
Counter argument	Text	0	0	3	0	1	1
	Diagram	0	0	1	0	1	0
	Graph	1	0	0	0	0	1
	Table	1	0	0	0	0	0
	Picture	0	0	2	0	1	3

PST's use of multiple representations for argumentation. Investigating the ways the participants used multiple representations changed in two ways. First, those who had naïve and transitional understandings used more than one representation to recite the same information. In other words, their use of representations included constraining functions of multiple representations. It was evident from the posters that these participants often used verbal-textual representations to explain in detail what the visual-graphical representations represented.

> In this table I want to show Germany's wind turbine system export. Directly next to it there is a written part. Maybe you don't see it. But it shows that the Japan, USA, France, Ireland are one of the most important energy export markets. In 2006, with almost 25 million dollars of export, Turkey comes in the 7^{th} place in the German export markets (Filiz, Poster presentation, video recording).

> Here you see the bar graph of Turkey's Electricity Generation Based on Different Resources in 2000, 2001, 2002, 2003 and 2004. It indicates that Turkey's current electricity is generated from fossil fuels. On the contrary, except 26% share of hydroelectricity; renewable energy resources such as geothermal, solar and wind has only 1% share (Filiz, Poster presentation, video recording)

However, the participants who had transitional and informed understandings used more than one representations to explain in detail what one representation indicated: constraining functions and to show different information sources to warrant two data sources to justify their claim: complementary functions.

Mustafa, for instance, had multiple sources of data in visual graphical representations. He first indicated Turkey's use of multiple energy sources and its dependency on fossil fuels. Then, he rebutted that these fossil fuels' environmental harms, fatal accidents occurred during fossil fuel transportation. Finally, he indicated the potential of Turkey on the solar energy use in a bar graph and a table.

> When we look at the energy sources' share in total energy consumptions; fossil fuels come in the first place [shows the table]. However, think about this, fossil fuels generation speed is 300.000 times slower than its consumptions. So, well, it shows that in the near future the sources of fossil fuels will be run out. But, look at this table here on the right. It shows how many hours the sun reaches in Turkey in each month. Well, each year in average it is 1311kwh/m^2 and this for the year 1996 is 11000 times… Comparing it [Turkey's solar energy potential] with the world, this bar graph, 1994-2007 data shows that Turkey itself has a big potential of photovoltaic energy. On the other hand, these pictures I put up here shows the solar panels. You can argue that the dirt on the panels reduce the electricity generation potential of these panels but they are easily washed out by the rain (Mustafa poster presentation, video recording)

It is evident from Mehmet's argument that he reads the text about the contamination of solar panels while showing the pictures which indicates the constraining functions of using multiple representations. On the other hand, he uses a table and a bar graph together to justify (construct) his argument about the Turkey's potential of solar energy which indicates the constructing functions of multiple representations.

Discussion and Conclusion

Scientists move between different representations for argumentation purposes in their daily practice. However, research suggests that PSTs do not fully engage in representational practices as scientists do in their daily practices (Roth, McGinn, & Bowen, 1998). One such reason might be PSTs' limited meta-representational competence, which refers to the ability of selecting, creating and using representations (diSessa, 2004). Findings of this current study further suggest that PSTs' argumentation understandings might be another reason for such limited representational practice.

First, the results suggested that the PSTs with naïve argumentation understanding failed to recognize the place of justifying claims in argumentation. This result is consistent with the findings of a previous study (Aydeniz & Ozdilek, 2015). Because students experience significant challenges to support their arguments with evidence (Sandoval & Millwood, 2005), it becomes critical to support this skills in science classrooms. One such practice is to incorporate representational practices to support argumentation. Studies suggest that when provided with representations students use evidence from representations to justify their claims (Mendonça & Justi, 2013; Pallant & Lee, 2015). Therefore, if the students understand argumentation, they might understand the importance of justifying claims and in return might use representations to support their claims.

Second, with the increased argumentation understanding the PSTs used multiple functions of multiple representations in their argumentation. The PSTs with increased argumentation understandings acknowledged the importance of justifying and validating the claims. Justifying and validating claims might require a learner to utilize multiple data sources to construct a sound argument. Some representations require individuals to utilize other types of representations to be interpreted. Visual graphical representations for instance involves a level of abstraction and might need to complemented with information from other modalities of representations (Ainsworth, 1999; Wu & Puntambekar, 2012). This can be attributed to construction function of multiple representations (Ainsworth, 1999). Therefore, with the increased level of argumentation understanding, PSTs use multiple representations to create sound arguments rather than repeating the same information from different representations.

Third, the use of multimodal representations differed regarding the PSTs' argumentation understandings. It was evident from the results that the PSTs used textual representations to recite their claims when they started presenting their arguments. This is similar to the results of previous studies where textual representation found to be an effective medium to recite claims (Hand & Choi, 2010). An expected reason might be that the text can be easily read off. Results also suggested that visual graphical representations helped the participants to rebut their points and synthesize counterarguments. Literature indicates that synthesizing counterarguments indicates sophisticated argumentation skills (Evagorou & Osborne, 2013). The participants with increased argumentation understandings could synthesize counterarguments based on the data in visual graphical representations. If we expect students to achieve such argumentation quality through the construction of rebuttals and counterarguments, we need to increase teachers understanding of utilizing visual graphical representations in argumentation through explicit teaching.

Literature indicates that argumentation opportunities for learners in science classes are rare (Osborne, 2010). To overcome this barrier, in recent years, scholars focused on developing new curricula (Sampson et al., 2011) and technology environments (Evagorou & Osborne, 2013). Using these new tools however, requires science teachers to have related prior experiences with argumentation. This further demands science teachers to value and understand the importance of argumentation in scientific inquiry and in science teaching (Sampson & Blanchard, 2012). Research suggest that teacher education programs should attend PSTs' knowledge of argumentation (Zembal-Saul, Munford, Crawford, Friedrichsen, & Land, 2002). Although the participants in this case study received formal training in science education, they failed to identify the roles of representations in argumentation.

Science methods courses can be effective means to enhance PSTs' pedagogical content knowledge skills (Avraamidou & Zembal-Saul, 2005). However, as Zohar (2008) argues teacher education programs, beyond focusing on specific elements of teaching argumentation, should "also address more fundamental issues pertain to pedagogy of knowledge construction" (p. 264). As the literature indicates that representations are fundamental tools for knowledge construction (DiSessa, 2004; Kozma, 2003), science teacher education programs should find ways to integrate argumentation and representational practices, in addition to explicit teaching of these two fundamental scientific practices. Although, the results might show some promise in uncovering the PSTs' views and practices of using representation in argumentation, the results should not be generalized beyond these participants.

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