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Original Article

Investigation of Middle School Students' Argumentation Schemes in Different Argumentative Orientations *

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Abstract

This study investigated 35 middle school students' argumentation schemes in two different argumentative orientations, namely, immersion orientation (i.e., learning of argument through immersion) and socio-scientific orientation (i.e., emphasizing the interaction between science and society) integrated into science instruction in the heat and matter and electricity units. The research design of this qualitative study is a single case and the study lasted six weeks. While students produced their first-hand data in immersion orientation, they used already available second-hand data (e.g., evidence cards) in socio-scientific orientation. Data were obtained from whole-class discussions, collected through classroom observations, and analyzed deductively. Findings showed students commonly used argument from position to know, analogy, and evidence to hypothesis in immersion orientation, whereas they used argument from sign, expert opinion, example, correlation to cause, and consequence mainly in socio-scientific orientation. These findings supported that the use of some argumentation schemes can depend on the type of argumentative orientation. A comparison of students' argumentation schemes used in different units when immersion orientation was used also suggested that the use of argumentation schemes is independent of the topic. Findings were discussed in detail regarding argumentation schemes and specific suggestions were provided.

Keywords

Argumentation
Argumentation schemes
Immersion orientation
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Introduction

Argumentation

Argumentation, a process involving competition, collaboration, and negotiation (Cavagnetto, 2010), starts in the human mind as intra-psychological argumentation by using reasoning skills through which evidence is interpreted and analyzed. Different pieces of evidence (e.g., physical evidence, digital evidence) are used to reach a conclusion by considering alternative views. In this way, initial arguments

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are formed after which inter-psychological argumentation that needs two or more minds begins and people aim to defend their arguments and defeat alternative arguments using their reasoning (Garcia-Mila & Andersen, 2007).

Previous argumentation studies mainly focused on argument quality (i.e., the product of argumentation process) (Sampson, Enderle, & Walker, 2012) to understand whether students acquired scientific knowledge through argumentation (e.g., Dawson & Venville, 2013), used the components of argument (e.g., claim) accurately (e.g., Jonsson, 2016), and linked the different components of argument (e.g., connecting data and claim) (e.g., Lin & Mintzes, 2010). Analysis of participants' argument quality, however, did not meet epistemic criteria, except for the use of argumentation schemes as an analytical framework (Duschl, 2007). Therefore, the current study utilized Walton's argumentation schemes to understand participants' arguments accurately and elicited the nature of argumentation schemes in middle school science classes as well.

Argumentation Schemes

Reasoning lies at the center of argumentation, and there are different types of reasoning. The first one is formal deductive reasoning. In formal reasoning, there is a system that includes a set of rules. Valid results are obtained when these rules are followed (Bronkhorst, Roorda, Suhre, & Goedhart, 2020). For instance, logic and mathematics use formal reasoning to reach a conclusion using their rules in a system. Another form of reasoning is informal reasoning, which requires more than simply applying the rules of logic. In informal reasoning, reasoning and conclusions are affected by context, arguments are open to debate and ill-structured, and there is no one correct response (Bronkhorst et al., 2020). For instance, individuals engage in informal reasoning when addressing socio-scientific issues, given that these issues are ill-structured and open to debate.

Another form of reasoning that aligns with informal reasoning is presumptive reasoning. Accordingly, presumptive reasoning is plausible and it includes provisionary correct reasoning when they are supported by the evidence. Presumptive reasoning can also be used to interpret and assess real-life arguments by evaluating premises. Premises are previously held representations that provide a reason to accept a conclusion (Mercier & Sperber, 2011). In line with this idea, Walton (1996) proposed argumentation schemes that use presumptive reasoning and posited (1996) that people use presumptive reasoning to form argumentation schemes when there is a lack of evidence.

These argumentation schemes are forms of arguments. Argumentation schemes are consistent with the arguments people use in their daily lives (e.g. arguments used in court). These argumentation schemes can be classified into 25 categories including argument from sign, argument from verbal classification so on (Walton, 1996; Walton, Reed, & Macagno, 2008). These argumentation schemes can also be used in the scientific context when scientists discuss with each other and in education when students discuss in science classes.

Critical questions can be asked about such schemes that reveal the quality of presumptive reasoning (Walton, 1996). For instance, consider a scenario where an individual claims to possess expertise within a specific domain and puts forth an assertion. To assess the soundness of the reasoning underlying this assertion, it becomes imperative to pose a series of pertinent questions. These questions encompass inquiries such as: "To what extent does the individual demonstrate proficiency in the subject matter?" (Expertise question); "Does the individual possess a bona fide expertise in the relevant field?" (Field question); "Can the individual be deemed a trustworthy source?" (Trustworthiness question); "Does the individual's assertion align with the consensus of other experts?" (Consistency question); and "What corroborative evidence supports the assertion?" (Evidence questions) (Baumtrog, 2021). The responses to these inquiries collectively contribute to our comprehension of the inherent quality of the presumptive reasoning that underlies the argumentation schemes.

Although these argumentation schemes are weak because they usually lack evidence, they can carry some evidence, contribute to the argumentation process, and change the direction of argumentation. Nevertheless, tentative conclusions can still be reached by utilizing these schemes. These tentative conclusions are, naturally, subject to change when new evidence and new argumentation schemes are defined (Walton et al., 2008).

Walton's argumentation schemes are also valuable for evaluating argument quality because argumentation schemes meet epistemic criteria by examining the nature and quality of a claim, how the claim is justified if a claim accounts for all alternative evidence, how the argument discounts alternative ideas, and how epistemological references are used to coordinate the claim and evidence (Duschl, 2007). Keeping this idea in our mind, we interpreted and analyzed middle school students' arguments using Walton's argumentation schemes in this study.

Despite argumentation schemes representing a precise method for assessing arguments (Duschl, 2007) and their alignment with the realm of science education (Macagno & Konstantinidou, 2013), research into the application of argumentation schemes has been notably limited within the domain of science education (e.g. Macagno & Konstantinidou, 2013; Özdem, Ertepinar, Cakiroglu, & Erduran, 2013). This stands in contrast to their extensive utilization in various other disciplines, including advertising (Schellens & De Jong, 2004), law (Prakken, 2010), criminal cases (Bex & Verheij, 2012), history and philosophy (Walton, 2019), and medicine (van Eemeren, Garssen, & Labrie, 2021). Hence, a challenge arises within the domain of science education when the assessment and evaluation of students' arguments are undertaken. This study, therefore, adopts an argumentation scheme framework to scrutinize the argumentative practices of middle school students. This approach seeks to offer potential resolutions to the challenge of effectively appraising students' arguments within the educational context.

Argumentation implementations do not always have the same characteristics. For example; Erduran and Pabuccu (2012) prepared chemistry stories to teach and evaluate arguments for the students. However, Hand, Wallace, and Yang (2004) prepared science writing heuristics (SWH) to engage students in inquiry-based argumentation. Theoretically, both of these are examples of argumentation implementations, but they have different philosophies for teaching and include different activities. While Erduran and Pabuccu (2012) used stories as context for argumentation and provided evidence cards (i.e., second-hand data) to assist students in producing arguments, Hand et al. (2004) immersed students within scientific investigations through SWH, wherein the data generated by students constituted first-hand observations. These variations in the implementation of argumentation practices yield distinct argumentative orientations, which are comprehensively elucidated in the theoretical framework section.

Given the limited scrutiny of argumentation schemes within the realm of science education, a corresponding omission has been observed in investigations comparing distinct argumentative orientations. While examining argumentation schemes within a singular orientation is undoubtedly informative, a more comprehensive approach entails the examination of argumentation schemes within two contrasting orientations. Such a dual focus not only furnishes insights into the characteristics of each orientation but also allows discerning potential convergences and divergences between them.

Consistent with the scarcity of research about argumentation schemes in science education, and the comparison of different argumentative orientations, these schemes also were not studied in different science units. However, studying argumentation schemes in different science units can be important similar to argumentative orientations because different science units have different content knowledge, and they require different skills, prior knowledge, and curricular objectives. All these differences carry different science units into different contexts. Therefore, we think that studying argumentation schemes in two science units extends our knowledge about argumentation schemes in science education further.

Theoretical Framework

Characteristics of argumentation interventions let us comprehend researchers' orientations in a given intervention context and these orientations are called argumentative orientations (Cavagnetto, 2010). The theoretical framework of the study was determined based on different argumentative orientations. Accordingly, there are three orientations for argumentation, namely, learning of argument through immersion (i.e., immersion orientation), teaching the structure of the argument (i.e., structure), and emphasizing the interaction between science and society (i.e., socio-scientific orientation) (Cavagnetto, 2010). Of these, immersion orientation includes all the elements of science (e.g., controlling variables). Structure and socio-scientific orientations, however, do not provide an opportunity for students to understand all the elements of science (Cavagnetto, 2010). For example, students do not conduct experiments in the last two orientations. As students conduct their investigation in immersion orientation, they produce their data during the investigation, meaning the students use the first-hand data they produced in their work. On the other hand, students do not produce (first-hand) data in structure and socio-scientific orientation as they do not conduct an investigation. According to Cavagnetto (2010), teachers teach argument components to students in structure orientation and ask them to use these learned argument components in different contexts by explaining the observed natural phenomenon. By contrast, socio-scientific orientation aims to understand the interaction between science and society. Socio-scientific issues (e.g., renewable vs. non-renewable energy sources) are a context for socio-scientific orientation. Class debates and role-play are typical activities used in socio-scientific orientation. In addition, moral, ethical, and political values are as important as scientific content knowledge in socio-scientific orientation (Cavagnetto, 2010). As students do not conduct an investigation in structure and socio-scientific orientation, second-hand data sources such as evidence cards can be provided to students in structure and socio-scientific orientation. Students can construct their arguments by using such sources.

In this study, we specifically aimed to understand middle school students' use of argumentation schemes. The students find opportunities to reveal their argumentation schemes in these three argumentative orientations. We think that students can benefit from different argumentative orientations in different ways as the activities of different orientations are different from each other. Therefore, we selected two of the three orientations which are immersion and socio-scientific orientation which have different characteristics. In this way, we could understand better students' use of argumentation schemes compared to a study that deals with only one of the proposed argumentative orientations.

On the one side, we used immersion orientation in which students conducted investigations and engaged in argumentation using the data they produced from investigations (first-hand data). We used Science writing heuristics (SWH), a specific type of argument-based inquiry (Hand, Norton-Meier, Gunel, & Akkus, 2016), as the immersion orientation in which students collect data, make reasoning to construct their arguments, discuss with their peers, negotiate with others, and consider second-hand data already available in other sources such as textbooks (Chen, Hand, & Park, 2016). On the other side, we used the socio-scientific orientation in which students did not conduct an investigation but instead used evidence cards (second-hand data) to produce arguments. In line with the socio-scientific orientation, the information in the included evidence cards focuses on the interaction between science and society and emphasizes moral, ethical, and political considerations. We also added scientific content knowledge to be used by students during whole-class discussions. Small-group investigation in immersion orientation was limited to reading and understanding the evidence cards provided in socio-scientific orientation. Table 1 summarizes the two argumentative orientations used in this study:

Table 1. Comparison of immersion and socio-scientific orientation (Cavagnetto, 2010)

Characteristics	**Immersion Orientation**	**Socio-scientific Orientation**
Aim	Learning science by engaging in inquiry and argumentation	Understand the interaction between science and society through argumentation
Elements of Science	Both process (e.g. data collection) and product (i.e., content knowledge)	Product (i.e., content knowledge)
Data Source	Mainly first-hand data	Second-hand data
Activities	Inquiry-based activities (e.g. conducting experiments)	Class debate, role play
Emphasis	Science content	Both science content and values (e.g. moral, ethical, political)

Literature Review

This study aims to understand middle school students' argumentation schemes in different argumentative orientations and different science units. Therefore, the literature review includes two parts which are studies about argumentation schemes considering argumentative orientations and studies on argumentation schemes in different units.

Studies about Argumentation Schemes Considering Argumentative Orientations

Although the use of argumentation schemes is a good way to interpret and analyze students' arguments (Duschl, 2007), previous research found that different argumentative orientations (Cavagnetto, 2010) affected the arguments produced in that context. Therefore, another focus of the study is argumentative orientation.

Despite prior research encompassing examinations of argumentation schemes and argumentative orientations, our comprehensive review has not revealed any prior investigations specifically probing into the dynamics of how the utilization of argumentation schemes may vary contingent upon different argumentative orientations. On the other hand, some studies attempt to understand participants' argumentation schemes. Duschl (2007) found that groups learning argumentation use argumentation schemes more than others who do not get such training. Likewise, Macagno, Mayweg-Paus, and Kuhn (2015) reported that students can improve how they use argumentation schemes when experts (i.e., scientists) criticize and fault their arguments. In another study held with pre-service teachers, Konstantinidou and Macagno (2013) reported that pre-service teachers mainly use the argument from cause to effect scheme because their background knowledge is conducive to this. Although the abovementioned studies focused on argumentation schemes, none of them adopted immersion or socio-scientific orientation. Moreover, we examined several additional argumentation studies that did not explicitly delineate a particular argumentative orientation. Our findings suggest that students in those studies likely employed argumentation schemes, albeit without the primary intent of the study authors. For instance, Emig, McDonald, Zembal-Saul, and Strauss (2014) employed analogical mapping-based instruction in an argumentation study centered on the topic of simple machines. It is plausible that students may have employed argument from analogy schemes when exposed to analogical mapping-based instruction. Similarly, students may have utilized argument from sign schemes when drawing inferences from analogies. Similarly, researchers reported students asked questions when analogies were presented, so students might use the argument from position to know scheme. Likewise, Emig et al. (2014) reported students constructed some wrong analogies, and so it is possible that students used argument from correlation to cause leading wrong explanations. Similarly, Mendonça and Justi (2014) presented modeling activities in an argumentation study related to chemistry topics like chemical bonding. As students made inferences on the presented models, they probably used argument from sign in this study.

The authors found only one study investigating argumentation schemes by adopting immersion orientation. In that study, Özdem et al. (2013) examined pre-service teachers' argumentation schemes and reported that pre-service teachers mainly use the argument from sign scheme during experiments, and use the argument from correlation to cause in class discussions. Moreover, pre-service teachers were found to use argument from correlation to cause, argument from sign, and argument from evidence to hypothesis at the undergraduate level (Özdem et al., 2013).

As previous studies using immersion orientation did not focus on argumentation schemes except Özdem et al. (2013), we further examined the studies using immersion orientations and interpreted their results in terms of argumentation schemes. First, Hand et al. (2004) used SWH and students made inferences about their writings, so they might use the argument from sign. Likewise, the groups formed their research questions, so they most probably used argument from position to know. Second, Grimberg and Hand (2009) used immersion orientation and reported students made reasoning operations that included questions and inference. Therefore, these students might have used argument from sign and argument from position to know schemes. As students used the evidence actively during SWH, they might use argument from evidence to hypothesis. Researchers also reported students produced regularity from their experiences, so they might actively use argument from example in this process. Third, Walker and Sampson (2013) used argument-driven inquiry (ADI) which was another form of immersion orientation. Walker and Sampson (2013) reported students consulted the teacher as authority when their claims are different from each other, so students might use argument from expert opinion in such cases. Researchers added that students did not examine the sources of errors and they were concerned about the result of experiments more than the process in the initial weeks of the study, so it is possible that students used argument from correlation to cause in those weeks. Fourth, Chen et al. (2016) used argument-based inquiry (ABI) as an example of immersion orientation. In this study, researchers asked students to explain their drawings. While students explained the drawings, they might use the data in the drawings and make inferences, so they might use argument from sign. Likewise, students might use argument from position to know as they used testable questions.

Previous studies using socio-scientific orientation also did not focus on the argumentation schemes, but still, we can see the traces of argumentation schemes in previous research using socio-scientific orientation. Accordingly, Dawson and Venville (2009) reported students mainly used intuitive and emotional reasoning and they did not use data so much in the socio-scientific context; therefore, it is possible that students used argument from correlation to cause. In another study, Tomas and Ritchie (2015) studied with 13-14-year-old students on the biosecurity topic. The students were asked to search before writing an article in this study. After students search for information, they might make inferences on this search and use argument from sign when they prepare written texts. Likewise, students used science articles before writing their articles and they might see these articles as authority, so they might use argument from expert opinion when they write their articles. Similarly, Namdar and Shen (2016) studied multiple representations including analogy, verbal explanation, and written texts in their argumentation study using socio-scientific orientation. Students might use data found in multiple representations, make inferences about them, and use argument from sign. Likewise, students might use argument from analogy as they benefit from the analogies presented as part of the multiple representations. Likewise, Namdar and Shen (2016) reported students formed small groups and asked questions to each other in the argumentation activity, and students might use the argument from position to know in this activity. The researchers also reported that students used their experiences as examples, so students might use argument from example.

Although studies of argumentation schemes do exist, as explained above, none of them focused on comparing students' argumentation schemes in different argumentative orientations (immersion vs. socio-scientific). To eliminate this gap in the literature, the current study examines argumentation schemes to accurately learn the nature of students' arguments in different orientations.

Studies on Argumentation Schemes in Different Units

To the best of our knowledge, only one study (Özdem et al., 2013) examined how students' argumentation schemes change from one task to another. Özdem et al. (2013) reported that the type of task affects pre-service teachers' use of argumentation schemes in immersion orientation. The researchers reported participants mainly used argument from correlation to cause in three of the tasks and mainly argument from sign in the other three tasks. Although this study provided information about how the use of argumentation schemes changes from one task to another at the undergraduate level, we did not find such research at the middle school level, but we did find two studies examining how students' argumentation skills change from one topic to another. In one study using socio-scientific orientation, Foong and Daniel (2013) tested whether secondary school students transfer their argumentation skills from a familiar context, namely, genetically modified organisms (GMO), to an unfamiliar context, deforestation. The findings showed that students generally developed argumentation skills from familiar to unfamiliar contexts, meaning they could transfer their argumentation skills. Students reportedly used more rebuttals in the unfamiliar context. In another study adopting the socio-scientific orientation, Khishfe (2014) examined whether middle school students transfer their nature of science (NOS) understanding and argumentation skills from the familiar water fluoridation context to the unfamiliar GMO. Students who took explicit NOS instruction combined with argumentation instruction developed their NOS views and argumentation skills and transferred them to the unfamiliar context. However, although students who only took explicit NOS instruction could develop their NOS views and argumentation skills, they could not transfer their argumentation skills to the unfamiliar context. Hence, students need argumentation instruction to be able to transfer their skills into an unfamiliar context (Khishfe, 2014). As a result, no study was found that compared middle school students' argumentation schemes in different units and not enough information was documented showing whether middle school students transfer their use of argumentation schemes in different units. By applying argumentation instruction in two different science units and using Walton's argumentation schemes, this study can further enlighten our understanding of the nature of argumentation schemes.

As students' use of arguments can be related to the type of argumentative orientation, the use of arguments can change from one science topic to another (Khishfe, 2014). For that, this study investigated students' argumentation schemes in the context of two different science units (heat and matter and electricity) taught in Grade 6. While immersion orientation was used to teach the electricity unit objectives and half of the objectives in the matter and heat units, socio-scientific orientation was used to teach the other half of the objectives in the matter and heat unit, which includes socio-scientific issues such as energy sources. As there was no objective in explaining natural phenomena without conducting an investigation in these units, this study did not use structure orientation. Therefore, we focused only on immersion and socio-scientific orientations.

The Topics

Before the study, we needed to select topics. Therefore, we examined the middle school curriculum. As the study focused on immersion orientation and socio-scientific orientation, we examined the content of each unit. Then, we selected the heat and matter unit as this unit included experiments about heat conductivity and heat insulation. This aspect of the heat and matter unit was consistent with the immersion orientation. Likewise, the following part of the same unit included core ideas about thermal insulation at home and renewable and non-renewable energy sources. This part matched with the socio-scientific orientation. By comparing students' argumentation schemes in the same unit with different orientation types (immersion vs. socio-scientific), we thought that we could find some clues regarding how the use of argumentation schemes changes in different orientations.

Therefore, we selected the heat and matter unit as the first topic of the study. The duration of the study was going to last four weeks, but previous research reported the duration of the argumentation studies should not be short as students can not benefit from the short-term studies (Hong, Lin, Wang, Chen, & Yang, 2013). Therefore, we selected one more science unit which was electricity to be studied. The electricity unit included fewer objectives compared with the heat and matter unit, and the objectives were about conducting investigations. Therefore, the electricity unit was consistent with immersion orientation. Adding electricity unit as the second topic of the study provided two advantages for the study. First, we could compare students' argumentation schemes in different units (matter and heat vs. electricity) when the same orientation (i.e., immersion) was used. Second, the use of one more unit would improve the duration of the study and students could better adapt to the argumentation and benefit from it further.

Significance of the Study

Argumentation schemes assist us in understanding the reasoning underlying these schemes (Macagno & Konstantinidou, 2013). In this way, implicit reasoning can become accessible and people's arguments are more accurately evaluated compared to other argument analysis ways such as examining the justification or rebuttal (Duschl, 2007). Despite the significance of argumentation schemes in the analysis of arguments and their congruence with the realm of science education (Macagno & Konstantinidou, 2013), their application within the domain of science education has been relatively infrequent. The existing literature on this topic remains limited, with only a few studies in the field of science education (e.g., Konstantinidou & Macagno, 2013; Özdem et al., 2013). Consequently, it can be asserted that prior argumentation studies, which have overlooked the incorporation of argumentation schemes, may not fully satisfy the epistemic criteria for assessing argument quality as delineated by Duschl (2007). Hence, there exists a pressing need for research endeavors aimed at exploring the role of argumentation schemes within science education, thereby enhancing the capacity to evaluate students' arguments more effectively. In line with this, this study aims to uncover the nature of the argumentation schemes used in middle school science classes.

The current study has the potential to contribute substantively to the development of the theory of argumentation because the theory of argumentation is constructed on the argumentation studies and argumentation studies' results are based on the analysis of arguments. As argumentation schemes offer an accurate way of analyzing arguments' quality, the theory of argumentation can be constructed more accurately when argumentation schemes are used in argumentation research.

Furthermore, there is no one type of argumentation and argumentation implementations have different characteristics and activities that form different kinds of argumentative orientations (Cavagnetto, 2010). These different characteristics of argumentative orientations might create different contexts in which the participants make different reasonings. These different reasonings can also be understood by the use of argumentation schemes, and this can assist us in understanding how people's reasonings converge and diverge from each other when different argumentative orientations are the case. This situation can further increase our understanding of the argumentation schemes as the study informs the use of argumentation schemes in different orientations. As previous argumentation scheme studies did not focus on different argumentative orientations, the current study increases our understanding of the connection between argumentation schemes and argumentative orientations.

Practically, if students' use of some argumentation schemes is specific to one argumentative orientation, this means that assisting students with their use of such schemes in that orientation is easier than assisting students when they reveal schemes that are not unique to that orientation. Therefore, teachers can prepare activities that facilitate the use of schemes fitting with the corresponding argumentative orientation. This can be the easiest way to activate students' possible argumentation schemes. However, this does not mean that teachers do not assist students' use of argumentation schemes that do not fit with that argumentative orientation. In such cases, teachers may need to spend more effort to assist students' use of such schemes because the corresponding argumentative orientation is not a suitable context that supports the use of these schemes. In conclusion, teachers can facilitate students' use of argumentation schemes by spending less or more effort depending on the argumentative orientation and this support directly feeds students' reasonings and learnings as students use more argumentation schemes with increasing frequency.

Next, this study can inform us whether the use of argumentation schemes depends on the science topic. By comparing argumentation schemes in different science units (heat and energy unit vs. electricity unit) the study will show us whether the use of argumentation schemes is independent of specific science topics or not. If students use the same argumentation schemes in different science units, this will show that students can transfer their acquired presumptive reasoning skills to different contexts (i.e., science units). If these reasoning skills are transferred, this means that middle school students can be taught how to improve their presumptive reasoning and argumentation schemes. After such training, students will be able to transfer their argumentation schemes to other science units, engage in argumentation more, and learn science better. However, if the use of argumentation schemes changes based on the science unit, this might provide some evidence that the use of argumentation schemes does depend on the science unit. If this possibility happens in the current study, researchers and teachers who only deal with the matter and heat and electricity units can benefit from this study because this study does not tell us about the argumentation schemes used in other science units.

The final significance of the study can be about teacher training in argumentation implementation. In this study, we studied with a teacher who did not have familiarity with argumentation as discussed in the procedure part of the method section. As described in that section, we spent six sessions to make the teacher familiar with both argumentation and implementation of argumentation in class. The steps we followed in this process can be also used by researchers for other argumentation studies when their implementing teacher is not familiar with argumentation.

Overall, the purpose of the study is to shed light on the nature of middle school students' argumentation schemes. It therefore seeks answers to the following two research questions:

1. Does middle school students' use of argumentation schemes change depending on different argumentative orientations (immersion vs. socio-scientific)?
2. Does middle school students' use of argumentation schemes change depending on different science units (matter & heat and electricity) in the immersion approach?

Method

Research Design

Qualitative studies are conducted to answer research questions that aim to explain natural phenomena (Fraenkel, Wallen, & Hyun, 2012). In this study, we specifically aim to understand whether middle school students' use of argumentation schemes changes in different argumentative orientations and different science units and we attempt to explain why the use of argumentation schemes changes or not in different orientations and science units. As we aim to explain students' use of argumentation schemes in different contexts (e.g., orientation, units), our study is an example of qualitative research.

A case study is an in-depth description and analysis of a bounded system (Merriam, 2009). Case studies focus on a single entity called a case and cases have boundaries. These boundaries determine what is to be studied or not (Merriam, 2009). In the current study, we aimed to understand 6th-grade students' use of argumentation schemes in different orientations and science units when argumentation implementation was carried out. The argumentation implementation was the unknown entity with its boundaries to be discovered in terms of students' use of argumentation schemes. Therefore, the argumentation implementation fit with the case study research design, and our particular case in this study was the six weeks long argumentation implementation. The boundaries of the study include pre-discussions, pre-lab activities, conducting investigations, analyzing evidence cards, negotiation phases that students followed during argumentation, students' reflections, and reviewing the content in the heat and matter unit and electricity unit. There are two main kinds of case studies which are single case studies and multisite case studies. If researchers examine one particular case, this is a single case and if researchers focus on different cases with different characteristics to understand an entity, that is a multiple case study (Merriam, 2009). In this study, our particular case was only the argumentation implementation, so this study is an example of a single case study. We tried to understand students' argumentation schemes through argumentation implementation and carried out the study with two similar classes. The classes were similar in many aspects. For example, they had similar achievements, socioeconomic status, and gender proportion, and both classes were taught by the same teacher with the same methods. Therefore, these two classes were thought of as two sub-units of this case study, and they were not taught as two separate cases as there were no specific characteristics that made them substantially different from one another.

Participants

The qualitative research does not aim for generalization, so purposive sampling is done in qualitative research and purposive sampling begins with criterion-based selection (Merriam, 2009). We had two main criteria for participant selection. First, we needed classes that are familiar with student-centered instruction as argumentation teaching is consistent with student-centered instruction. Second, we needed students from grade 6 as the heat and matter unit and electricity unit were taught in this grade level. The students and implementing teacher who met these criteria were selected as participants in the study. Among different types of purposive sampling, we used convenience sampling as we select participants depending on time, cost, location, and availability of participants (Merriam, 2009).

The study included 35 Grade 6 Turkish students (ages 11-12) enrolled in two classes of a well-equipped public school. The school had a science laboratory including several benches, faucets, and laboratory materials like experiment sets, and beakers. The study was conducted in this laboratory. We used the benches as locations for the groups, so benches facilitated the group work. Likewise, we benefitted from the faucet to conduct matter and heat experiments when we needed water at different temperatures. Likewise, the experiment materials like electrical circuits were useful for carrying out electricity units. While one of the classes consisted of nine girls and eight boys with a mean science grade of 77.33 in the previous semester, the other class comprised eight girls and 10 boys whose mean science grade was 73.76. Before this study, both classes followed the same curriculum suggested by the Ministry of National Education [MoNE, 2013]. During the study, heterogeneous groups of four or five students were formed based on their science achievement and gender. When we formed a group, we thought that the classes represented the society and the society included people having different genders, achievements, cultures, and backgrounds. Therefore, we tried to form heterogeneous groups including students having different characteristics. For example, each group included one male or female student. Likewise, the implementing teacher informed us about students' science achievement. Depending on this information, we placed at least one low achiever and one high achiever in each group. To protect students' rights, we used pseudonyms. Accordingly, each student got a three-digit code. The first digit represented their class number, the second digit showed their group number, and the last digit indicated their sitting place in the group. For example; student 243 addressed the second class's fourth group's third student.

Specifically, during the procedure, students in both classes worked in groups and enrolled in a 6-week argumentation course focusing on both immersion orientation (weeks 1-2-5-6) and socio-scientific orientations (weeks 3-4). This argumentation course was integrated into grade 6 students' regular science course and students participated in this study when heat & matter and electricity units were taught. The reason why the study started with the immersion orientation, continued with socio-scientific orientation, and ended with immersion orientation is the curricular obligations that teachers have to follow. Accordingly, teachers have to teach curricular objectives offered by the MONE. The heat and matter unit included four objectives and the first two objectives were consistent with immersion orientation as students were asked to perform investigations in these objectives. Therefore, immersion orientation was used for the first two weeks. On the other hand, the last two objectives of the heat and matter unit were in line with socio-scientific orientation. Therefore, socio-scientific orientation was used in weeks 3 and 4. The next unit was the electricity including two objectives. Both objectives of the electricity unit included electricity experiments, therefore, immersion orientation in which students experimented was used in the last two weeks of the study.

Procedure

Preparation of Lesson Plans

A total of six lesson plans were prepared consistent with argumentative orientations in selected units before the study began. Four lesson plans were prepared for immersion orientation and two lesson plans were prepared for socio-scientific orientation. Implementation of each lesson plan lasted four lessons (i.e., one week). When we prepared lesson plans, we were inspired by SWH for the immersion orientation. These lesson plans included titles as objective, revealing students' ideas, pre-lab activities, lab activities, experiment materials, negotiation phase-1 (i.e., forming individual arguments), negotiation phase-2 (i.e., forming group arguments), negotiation phase-3 (i.e., whole class discussion), negotiation phase-4 (i.e., student reflections), and evaluation. The content of the lesson plans for socio-scientific orientation included similar titles, but these lesson plans included engaging in the activities title instead of lab activities as students were expected to analyze evidence cards in socio-scientific orientation. After we prepared lesson plans, we got expert opinions from two experts who studied argumentation. The experts mainly told us we should increase the uncertainty in the activities because students engage in argumentation more when there are no definite results of the activities. Then, we made adjustments to the lesson plans by increasing the uncertainty of the activities.

Teacher Selection and Teacher Training

Then, the implementing teacher was selected. The selection criteria were the same as the student selection. Accordingly, working in grade 6 level and using student-centered instruction in class were two criteria to select the teacher and we found a teacher having these aspects.

The teacher was female and had 10 years of teaching experience at the middle school level. She was working in a public school and the school was located in one of the central districts of Ankara. Although the teacher said that she used discussion in her class, she was not familiar with argumentation. Therefore, the teacher was trained for argumentation.

Specifically, the teacher training lasted six sessions and each session lasted 1 hour. The characteristics of science were discussed with the teacher in the first session. For example; what makes science different from other ways of knowing was discussed. The second session topic was science process skills. As the immersion orientation is directly related to science process skills, we discussed about the basic and integrated process skills in this session and the teacher was found knowledgeable about science process skills. After that, the nature of scientific knowledge was discussed with the teacher in session three. In this session, we aimed to improve teacher's beliefs about science (e.g., tentativeness) because these beliefs support understanding the argumentation (Weinstock, Neuman, & Glassner, 2006). The next session was argumentation and we aimed to make the teacher familiar with the argumentation. The discussion was on the argumentation process and the components of an argument (e.g., claim, data, rebuttal). After the teacher became familiar with argumentation, we presented the argument-based inquiry. By doing this, we aimed for the teacher familiar with the use of argumentation as a teaching approach. In the last session, we discussed the ways of assessing argumentation in class.

The Pilot Study

Afterward, a pilot study was conducted during which the teacher implemented the argumentation lesson plans. The pilot study lasted six weeks (6x4= 24 lesson hours) for each class as it was planned. Some adjustments were made to the lesson plans based on the feedback received from the pilot study. For example; we provided students with chickpeas when they conducted their heat transfer experiment in the first week. The students were expected to put the chickpeas in the butter and these chickpeas were going to fall when the butter melted. However, students did not use chickpeas in their experiment, but still, they were able to explain their experiment result, so we removed chickpeas from the main study as an adjustment. Likewise, students found some surprising results in their experiments during the pilot study. For example; students found that metal cup was better heat insulator. This result was also surprising for us and we looked for the reason for this result. Then, we found that this was due to the Mpemba Effect which means that the rate of heat transfer increases if the difference between initial and final temperatures is too much. As metal cups' initial temperature was low, they lost their heat slower compared to other cups (e.g., plastic), so students claimed that metals were good heat insulators. After this feedback, we focused on the percentage of heat loss instead of the difference between the initial and final temperature in the main study as an adjustment.

The Main Study

The main study was conducted a year later. The same teacher participated in the main study, but the students were different. The new students who were the participants of the main study were not familiar with argumentation. Therefore, the main study started with student training and continued with the argumentation implementation.

Student Training

The students were taught before the study began and their instruction included discussions about scientific inquiry, scientific debate, science, scientists, learning through inquiry, science process skills, and argumentation. The students were trained one week before the main study and lasted four lessons (i.e., one week). This training started with a presentation. In this presentation, we discussed the abovementioned topics. For example; we asked them how scientists work and understood their ideas about scientific inquiry. Likewise, we asked them about the difference between scientific debate and debates in daily life. Then, we asked them to compare scientists and themselves and they listed the similarities and differences between children and scientists. Next, we used a demonstration related to the density topic. We asked students which objects we threw into water sinks. Students asserted some claims and they explained their reasons and discussed them with each other. Then, we informed them they engaged in argumentation which is what we expected from them during the main study.

The Argumentation Implementation

Then, the argumentation implementation began. It lasted 6 weeks. Each week the teacher taught one of the core ideas, which are heat insulators, heat conductivity, thermal insulating products, renewable and non-renewable energy sources, electrical conductivity, and factors affecting bulb brightness.

In weeks 1-2-5-6, immersion orientation was used. This part was the same with the use of SWH. At the beginning of each week that immersion orientation was used, students engaged in pre-discussions. The teacher elicited students' ideas through these pre-discussions. Then, groups prepared their research questions considering the curricular objectives. For example; one of the groups focused on which type of cups conducts heat better. After that, the groups designed their experiments considering the research question. Next, group members conducted their experiments. In this way, students constructed first-hand data. Using this first-hand data, students formed their individual arguments. Then, students compared their individual arguments and formed group arguments through negotiations. When group arguments were formed, students presented their research questions, experiment results, and group arguments to the rest of the class. At this point, the whole class discussion started. When all groups presented their arguments and the class reached a consensus, the whole class discussion was completed. After that students shared their learnings to the rest of the class as their reflections. After students shared their learnings, the teacher provided feedback to the students regarding that week's content.

In weeks 3-4, socio-scientific orientation was used. Although the general flow of the lesson was the same as the lessons in immersion orientation were used, there were some subtle differences between the lessons in which different orientations were used. In socio-scientific orientation, pre-discussions were done at the beginning. Considering the pre-discussion content, groups formed their research questions. For example; one group's research question was 'Which type of energy should we use to heat our homes?'. Then, we provided evidence cards as second-hand data to all groups. These evidence cards provided data for students to answer their research questions. Some of the information in the evidence cards was not related to their research questions, so they analyzed the evidence cards to connect their research question with data. Then, students formed their individual arguments which was followed by the formation of group arguments. When all groups formed their group arguments, the whole class discussion started. When all ideas were discussed and all groups presented their work, the whole class discussion was completed. After the whole class discussion, the reflection phase started and students reported their learning in this phase. When students shared their learnings, the teacher provided feedback to the students about the content.

A summary of the entire procedure is presented in Figure 1.

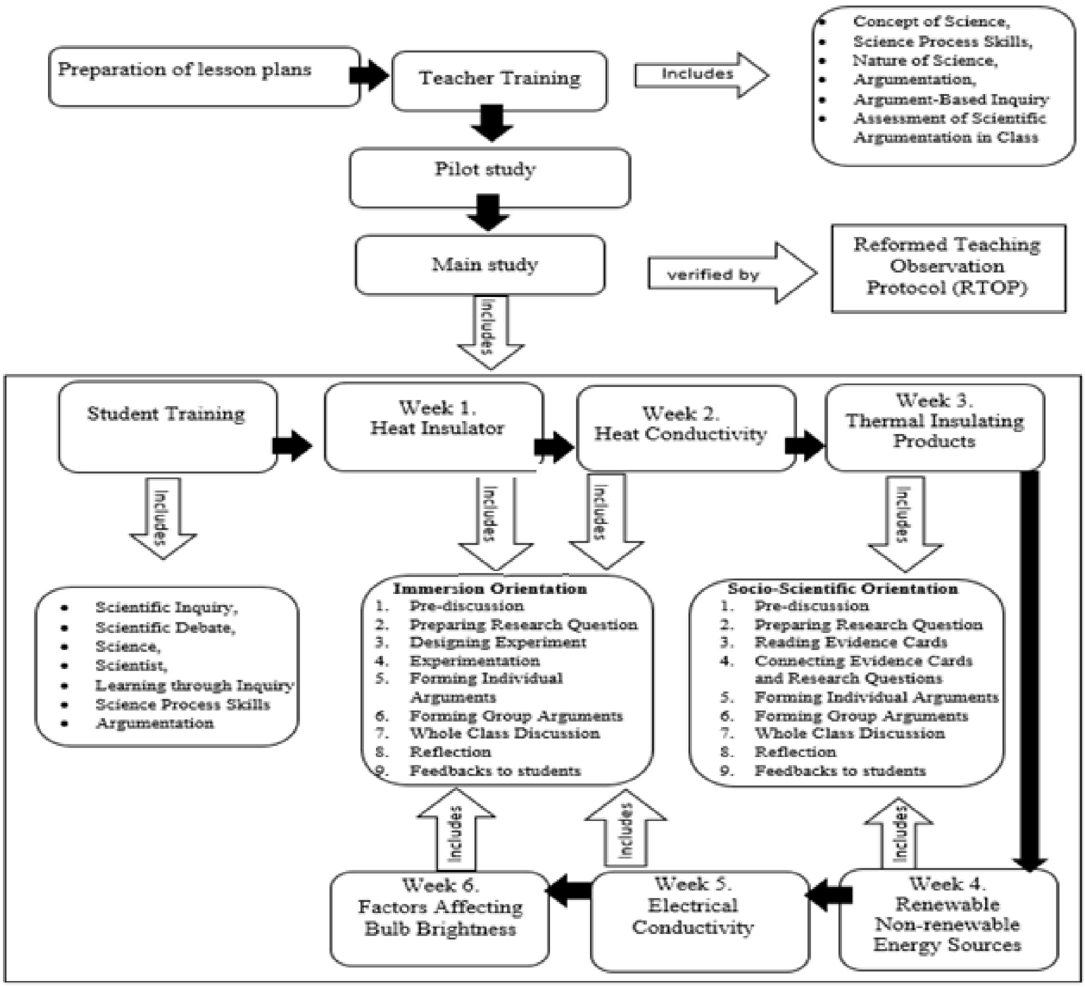

Figure 1. Summary of the Procedure

Data Collection

The data collection process included classroom observations of the researcher as a complete observer, the use of the reformed teaching observation protocol to verify argumentation implementation, and the use of video recordings to get evidence for data analysis.

Classroom Observations

Accordingly, the first author sat at the back of the students and observed the classroom events. The researcher did not take field notes during observation because each second was recorded by a video camera set at the corner of the class. The role of the researcher was the complete observer which means that the researcher did not participate in any activities and just observed what was happening in the class. The observation process included students' pre-discussions, their pre-activities like forming a research question, their investigations (e.g., experimenting), students' negotiations on their claims (e.g., forming group arguments), and whole class discussions. All these phases (e.g. conducting activities, forming group arguments) lasted two lesson hours for each week (i.e., 80 minutes) and prepared students for the presentations done in whole-class discussions which lasted 1 lesson hour for each week (i.e., 40 minutes). In whole class discussions, each group presented their research questions, group claims, and their reasons to the rest of the class. The class members asked questions, proposed counter-claims, or supported the presenting groups. In the last lesson (i.e., 40 minutes), students reflected on their learnings and the teacher provided feedbacks about topic.

The Reformed Teaching Observation Protocole (RTOP)

The Reformed Teaching Observation Protocol (RTOP) was used to verify argumentation. The RTOP includes 25 items and 13 of them can be used to assess argumentation quality in science class (Martin & Hand, 2009). Some of the items used in verification were about respecting students' prior knowledge, student-centered instruction, students' active engagement in the process, students' constructive criticism, challenging ideas, teacher questions leading to divergent modes of thinking, students' alternative perspectives, and different ways of interpreting evidence. RTOP items were used as a checklist and the first author filled the RTOP checklist by observing the teacher's argumentation implementation. After each lesson, the researcher shared the filled RTOP with the implementing teacher and the teacher modified her teaching in the next lessons considering the RTOP checklists.

Video Records

Each class was video recorded for four class hours a week. Overall, each class was observed for 24 class hours (i.e., 960 minutes) during the study. The researchers then transcribed the video records of the whole class discussions. Discussion episodes were then identified for each lesson. These discussion episodes obtained from the whole class discussions were used in data analysis.

Data Analysis

Data analysis began by identifying the start and end points of the discussion episodes. The start point of each episode was one student's idea of a new topic. The episode continued until a new discussion began on a different topic. Discussing the new topic marked the last point of the current discussion episode and the start point of the new discussion episode. We reached 85 discussion episodes in total. Some of the discussion episodes we analyzed were the heat transfer rate in different materials for the first week, the use of heat insulators in daily life for the second week, the use of insulation materials to avoid pests for the third week, a comparison of renewable energy sources like solar and wind energy for the fourth week, the electrical conductivity of salty water for the fifth week, and the relationship between wire thickness and the bulb brightness for the last week.

An example of the episode is presented below. The name of the sample episode is the relation between wire length and the bulb brightness:

Student 221: *We hypothesized that the length of the wire does not affect the bulb brightness because the same current would pass through the wire even though the wire length increases.* (Argument from evidence to hypothesis). However, it affected we do not know the reason.

Student 231: We examined the same research question. The length of the wire affects the bulb brightness because the *teacher told us there is energy loss when electricity passes through the wire.* (Argument from expert opinion). *If the wire length increases, the energy loss will increase. Therefore, the bulb brightness decreases* (Argument from evidence to hypothesis).

After that student 221 accepted student 231's argument and the class passed to the discussion of another topic. At this point, this episode ended.

When students propose their ideas, they make presumptive reasoning. Their presumptive reasoning appeals to some clusters of what we call argumentation schemes. Examining their reasonings in their statements, we can reach which argumentation scheme is available in that idea. Then, we can analyze the next statements and identify corresponding argumentation schemes. This sequence of identification of argumentation schemes through presumptive reasoning is the reasoning sequence. Therefore, the reasoning sequence in the episodes was the unit of analysis for the analysis of argumentation schemes (Duschl, 2007). For example in the wire length and the bulb brightness episode; student 221's statement and reasoning corresponded to argument from evidence to hypothesis as an argumentation scheme because there was a testable hypothesis that is supported or rejected by the use of evidence. Then, student 231 proposed a different explanation regarding why the bulb brightness decreases when the length of the wire increases. When student 231 made this explanation, he referred to the teacher's explanation as an expert opinion. Therefore, student 231's reasoning was coded as the argument from expert opinion. As it is seen, new reasonings let us reach new argumentation schemes. Therefore, the reasoning sequence was a unit of analysis for our study.

Each episode was then deductively analyzed to reveal the students' argumentation schemes. Duschl (2007) reported that analyzing argumentation schemes is difficult and he adapted the analysis of argumentation schemes to a middle school context. Likewise, when the argumentation schemes were analyzed, both Walton's (1996) explanations and Duschl's (2007) codes were used as deductive codes. For example, when the students made an inference about the experiment in an argument, such arguments were coded as argument from sign (Duschl, 2007; Walton, 1996). However, if the student ignored possibilities and preferred plausible, but scientifically lacking or incorrect arguments, such arguments were coded as argument from correlation to cause. Argumentation schemes, their definition, and their examples as used in the study are given in the Appendix.

Both researchers analyzed the data. Inter-rater agreement for argumentation schemes was found to be 80%. In this process, we (two of the researchers) used the transcriptions and code list (e.g. the list of argumentation schemes.). Then, we separately coded each of the 85 discussion episodes considering the argumentation schemes. We also took note of the reasoning behind each code. Then, we compared the results of each coding and we reached an inter-rater agreement rate. After that we tried to persuade each other for the conflicts and discussions lasted until we reached a consensus.

After the argumentation schemes were explicated, the total weekly frequency of each argumentation scheme was calculated. Using these argumentation schemes, we sought answers to the research questions. Accordingly, we compared the frequency and type of argumentation schemes used in immersion orientation weeks and socio-scientific orientation weeks to understand whether argumentation schemes depend on argumentative orientation. Then, we compared the frequency and type of argumentation schemes revealed in the different science units (matter and heat vs. electricity) in immersion orientation to understand whether the use of argumentation schemes changes based on different science units. As we used socio-scientific orientation in only one unit which was heat and matter, we could not use socio-scientific orientation to compare argumentation schemes in different units. Therefore, we used only immersion orientation when we wanted to compare argumentation schemes in different units (i.e., heat and matter vs. electricity).

The data analysis did not end at this point. After reaching the frequencies and percentages of each argumentation scheme, we applied inductive content analysis. In this process, we focused on the specific situations in which students use certain argumentation schemes. For example; our content analysis revealed that students mainly used argument from analogy when they compared their experiment and control group and explained abstract topics using some concrete things. This content analysis provided further information to understand the nature of argumentation schemes.

Trustworthiness and Ethical Issues

Validity is named as trustworthiness in qualitative research and the trustworthiness of the study was supported by credibility, dependability, and transferability of the study. Credibility is related to internal validity and it deals with the consistency between research findings and reality (Merriam, 2009). The credibility of the study was supported by triangulation, adequate engagement in data collection, researcher position, and peer review. Triangulation of the study was supported by the use of multiple data sources and multiple investigators. Accordingly, the transcriptions of the video recordings included multiple data coming from two classes and six different weeks. By comparing the data from different classes and weeks, multiple data sources contributed to triangulation. Likewise, researchers worked together as multiple investigators in the selection of a theoretical framework, data collection, and analysis of data, this process also supported triangulation. Adequate engagement in data collection also supported the credibility. Accordingly, researchers spent two years together with the implementing teacher and school staff. In this way, the researchers and school members became familiar with each other. When we became familiar with each other, we had a chance to observe teacher's and students' daily life behaviors which also increased the credibility of the research. The researcher's position was another thing supporting the credibility of the study. Accordingly, we were familiar with the argumentation process as we conducted argumentation research earlier, prepared lesson plans for it, and implemented argumentation lessons in science teaching courses. Furthermore, the pilot study increased our expertise in argumentation. All these events address the researcher's position which supported the credibility. Lastly, two experts in argumentation provided feedback throughout the study and the researchers cooperated in the preparation of the study, data collection, data analysis, and reporting. These cooperations as peer review contributed to the credibility of the study.

Dependability refers to the reliability of the qualitative study. Accordingly, results should be consistent with the data (Merriam, 2009). The dependability of the study was supported by the inter-rater agreement done by two researchers. The last thing supporting the trustworthiness of the study was transferability which refers to external validity. The findings of qualitative research can not be generalized, but the findings can be used by people having a similar context to this study. For example; teachers having grade 6 students in public schools can benefit from the study. Likewise, people can understand the study by looking at the thick description (e.g. procedure) we mentioned. Therefore, they can easily use the study findings for their aims.

Before conducting this study, ethical permissions were obtained from the University of researchers and the Ministry of National Education Ethical Committee. Furthermore, written and oral permissions were obtained from all participants and their parents. Pseudonyms were given to the students, so their personal information was not used in the study. Likewise, no participants were physically or psychologically harmed in the study. We acknowledged that students can withdraw from the study anytime they asked and we also informed them that their engagement in this study did not affect their course grades. Lastly, we did not share participants' data with a third person except the researchers and experts we consulted on.

Findings

Figure 2 shows the two participating classes' use of argumentation schemes throughout the study and Figure 3 shows the percentages for the use of argumentation schemes. We used these figures to achieve our results. The first part gives the findings about the use of argumentation schemes and the type of argumentative orientation. The findings about the use of argumentation schemes in different units (when immersion orientation was used) are reported next.

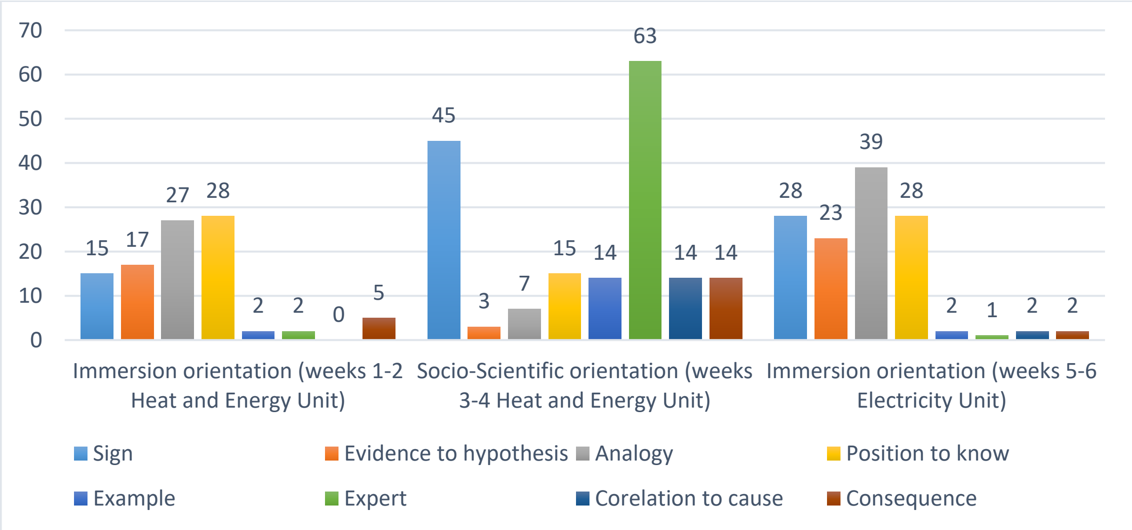

Figure 2. Frequency of Argumentation Schemes Used Throughout the Study

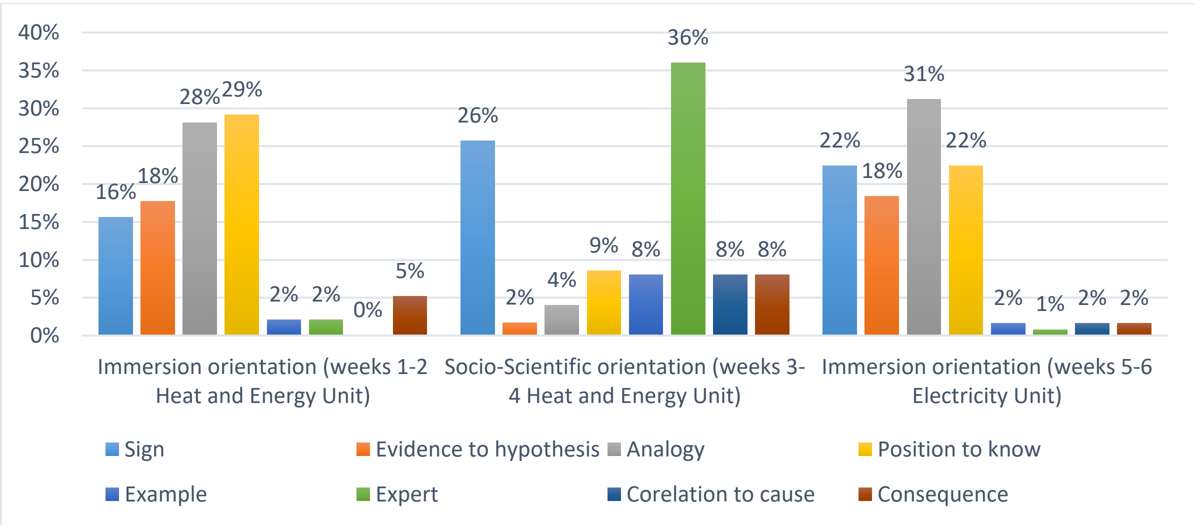

Figure 3. Percentages of Argumentation Schemes Used Throughout the Study

The classes engaged in argumentation 396 times throughout the study. They used argumentation schemes 96 times in the first two weeks (Immersion orientation -- Heat and Energy Unit), 175 times in weeks 3 and 4 (Socio-scientific orientation -- Heat and Energy Unit), and 125 times in the last two weeks (Immersion orientation -- Electricity Unit). The next part presents the results for the connections between argumentative orientation (immersion vs. socio-scientific) and the use of argumentation schemes.

Use of Argumentation Schemes and Type of Argumentative Orientation

We used the data coming from heat and matter unit to understand whether argumentation schemes change in different orientations. In this way, we kept the unit constant. Accordingly, we used immersion orientation in the first two weeks of the heat and matter unit and we used socio-scientific orientation in the last two weeks of the heat and matter unit. The unit lasted four weeks in total. A comparison of students' use of argumentation schemes in different orientations in the same unit (i.e., heat and matter) revealed that middle school students' use of argumentation schemes changes depending on argumentative orientation. Accordingly, the students preferred to use argument from evidence to hypothesis, argument from position to know and argument from analogy more in the weeks when immersion orientation was used. For example; the percentage of argument from evidence to hypothesis was 18% in immersion orientation, whereas it was only 2% in the socio-scientific orientation (see Figure 3). Likewise, the use of argument from position to know percentage was 29% in the immersion orientation while it was 9% in the socio-scientific orientation. Similarly, the use of the argument from analogy was 28% in the immersion orientation, but the use of this argumentation scheme decreased sharply in the socio-scientific orientation (4%).

By contrast, the students preferred to use the argument from expert opinion, the argument from sign, the argument from example, the argument from correlation to cause, and the argument from consequence more when socio-scientific orientation was used (see Figures 2-3). Accordingly, the percentage of argument from expert opinion increased from 2% to 36% when argumentative orientation changed from immersion to socio-scientific. Similarly, the percentage of argument from sign increased by 10 percent from 16% to 26%. The same trend was observed for the use of argument from example which percentage increased from 2% to 8%. Consistently, argument from correlation to cause was not used in the first two weeks of the heat and matter unit when immersion orientation was used, but this scheme was used in the last two weeks of the heat and matter unit (8%) when the socio-scientific orientation was used. Lastly, the use of argument from consequence increased from 5% to 8% (Figure 3). While students used this scheme only 5 times in immersion orientation, they used it 14 times when socio-scientific orientation was used (Figure 2).

Table 2 for immersion orientation and Table 3 for socio-scientific orientation provide excerpts of the argumentation schemes used by the students.

Table 2. Sample excerpts from the argumentation schemes used in immersion orientation

Argumentation Schemes	Excerpt
Position to Know	Student 113: In which cup did you conduct your experiment? (To obtain more information.) (Week 2 - Class 1)
Position to Know	Student 242: How did you measure a solid substance's temperature using a thermometer? A thermometer is used to measure the temperature of liquids or gases. (To show inconsistencies.) (Week 1 - Class 2)
Position to Know	Student 232: Why do metals conduct electricity better than other materials? (To understand theoretical explanation.) (Week 5 - Class 2)
Evidence to Hypothesis	Student 113: Our research question is: Which spoon conducts heat better? We hypothesize that the metal spoon is a better heat conductor. (Explaining group hypothesis.) (Week 1 - Class 1)
Analogy	Student 141: We put different spoons in hot water (70˚) for about two minutes. We placed butter on each spoon and the butter on the metal spoon melted before the others. Therefore, metal conducts heat better than plastic and wood. (Comparing concrete things.) (Week 1 - Class 1)
Analogy	Student 231: It is difficult to travel a long distance when compared with a short distance. Likewise, a long wire resists more current than a short wire. (Comparing abstract resistance topics to traveling different distances.) (Week 6 - Class 2)

When the content of the argumentation schemes was elicited, we observed that the students used argument from position to know to obtain further information about the presenting group's experiment, show inconsistencies in the presenting group's explanation, and understand the theoretical explanation of the presenting group's findings. Another scheme frequently used in the immersion weeks was argument from evidence to hypothesis and this was mainly used when the presenting group expressed their experiment, hypothesis, and results. Likewise, the argument from analogy was used when the presenting group compared their experiment group with the control group and related abstract topics to make a theoretical explanation for their results (Table 2).

Table 3. Sample excerpts from the argumentation schemes used in socio-scientific orientation

Argumentation Schemes	Excerpt
Sign	Student 223: Because the Earth rotates, one side of the Earth is always receiving solar energy, so we should use solar energy. (By using prior knowledge, the student makes inferences.) (Week 4 - Class 2)
Example	Student 231: We should use renewable energy sources. For example, wind energy can be used in mountains or high places. (By using examples, the student supports the main argument.) (Week 4 - Class 2)
Expert	Student 121: We should not use tar as an insulating product for interior walls because it is flammable, not durable, and used for ceilings. (The student used the information given in evidence cards as an expert/authority.) (Week 3 - Class 1)
Correlation to Cause	Student 111: Wood wool can be used as insulating material for exterior walls because wood wool is environmentally friendly. (There was no link between using wood wool for exterior walls and the concept of being "environmentally friendly.") (Week 3 - Class 1)
Consequence	Student 234: We should not use glass wool for heat insulation because when we use glass wool, we may suffer allergic reactions to it. (The student considers the negative effects of using glass wool when forming the argument.) (Week 3 - Class 2)

By contrast, other argumentation schemes were used more when the experiment was not conducted (i.e., socio-scientific orientation). For example, thermal insulation products and energy sources were topics related to their daily life. By using their prior knowledge, familiarity, and experiences, students could make inferences to construct their arguments and so they frequently used argument from sign. Likewise, the students used argument from example by providing examples from daily life to support their main arguments. Next, the students consistently used the information provided in evidence cards in their arguments as authority, so they actively used argument from expert opinion. In some discussion episodes, the students connected different phenomena as if there were a cause-effect relationship between them when there was none. Here, the students used argument from correlation to cause. Lastly, students sometimes considered the positive and negative consequences (e.g., health problems) of their selection when deciding which thermal insulation product should be used, so they used argument from consequence (Table 3).

In conclusion, it can be asserted that students' use of argumentation schemes varies depending on the type of argumentative orientation (immersion vs. socio-scientific). Next, we present the results for whether the use of schemes changes in different science units or not.

Use of Argumentation Schemes in Different Units

We compared the argumentation schemes used in different units (matter & heat and electricity) to see whether the use of argumentation schemes changed depending on different science topics. To avoid the effect of orientation on the use of argumentation schemes, we focused solely on the weeks that immersion orientation was used. Therefore, we compared the first two weeks' results for the matter and heat unit and the last two weeks' electricity results.

The findings suggested similar general trends regarding argumentation schemes for different science units in that the participants commonly used argument from sign, argument from position to know, argument from evidence to hypothesis, and argument from analogy in different science units. Accordingly, the students' use of the argument from analogy increased from 27 to 39 (Figure 2), but the percentage of the use of this scheme was similar in the heat and matter unit (28%) and electricity unit (31%) (Figure 3). Argument from sign also increased from 15 (16%) to 28 (22%) (Figures 2-3). Similarly, the use of the argument from evidence to hypothesis increased from 17 to 23 (Figure 2), however, the percentage of the use of this scheme remained the same in both heat and matter and electricity units (18%). By contrast, the students' use of argument from position to know remained the same (28 times) from the first two immersion weeks to the last two immersion weeks (Figure 2). Although the percentage of the use of this scheme decreased from 29% to 22% from matter and heat unit to the electricity unit, this scheme was still one of the most used argumentation schemes in two different units (Figure 3).

Although the students used these four argumentation schemes frequently in both the heat and matter (first two weeks) and electricity units (last two weeks), they did not use the other four argumentation schemes (e.g., argument from expert opinion) as much in both the units when immersion orientation was adopted. For example; the use of the other four argumentation schemes (e.g. argument from correlation to cause) did not pass 5% in any of the two units and the percentage of the use of these schemes was mainly 2% or less (Figure 3). We conclude that the use of some argumentation schemes is consistent with immersion orientation and that the type of argumentation schemes used by students may not change in different science units when immersion orientation is implemented.

Discussion

This study specifically focused on middle school students' use of argumentation schemes in different orientations (i.e., immersion vs. socio-scientific) and different science units (i.e. heat and matter vs. electricity). When we focused on the orientation, we kept the science unit the same. For example; we only examined data coming from the heat & matter unit and two different orientations were used in this unit. On the other hand, when we focused on the science unit, we used two units and one orientation (i.e., immersion). In this way, we kept the argumentative orientation the same. The findings of the study showed that students' use of argumentation schemes might change in different argumentative orientations, but the use of argumentation schemes seemed to be similar in different science units when the same orientation (i.e., immersion) was used. In the discussion part, first, the findings about the use of argumentation schemes in different argumentative orientations are discussed and then the findings for the use of argumentation schemes in different science units are discussed.

The Use of Argumentation Schemes in Different Argumentative Orientations

The Use of Argumentation Schemes in Immersion Orientation

First, this study examined students' argumentation schemes used in different argumentative orientations. Immersion orientation includes both the process of science and its product and is consistent with both the material and social aspects of science. However, socio-scientific orientation includes only the product of science and its social aspect. Therefore, it can be said that immersion orientation represents science better than socio-scientific does (Cavagnetto, Hand, & Norton-Meier, 2010). The results for the argumentation schemes used in different orientations reflect the distinction between both orientations. In this study, students used argument from position to know, argument from evidence to hypothesis, and argument from analogy more frequently in immersion. As immersion represents science better, we think that the schemes used more in immersion -- argument from position to know, argument from evidence to hypothesis, and argument from analogy -- could work as scientific argumentation schemes in middle school science classes.

According to Lederman and Lederman (2012), scientific inquiry starts with asking a question. The participants frequently used argument from position to know to look for further information and theoretical explanations and to address inconsistencies in experiments in this study. Similar to argument from position to know, the participants used argument from evidence to hypothesis in immersion orientation. Özdem et al. (2013) reported that argument from evidence to hypothesis is a scientific scheme as students verify or refute claims by using argument from evidence to hypothesis. Likewise, Kind, Kind, Hofstein, and Wilson (2011) reported that students research, formulate more hypotheses, and contemplate evidence more if they produce data. In this study, immersion orientation let the students produce data, so students could frequently use argument from evidence to hypothesis more in this orientation.

Next, the students used argument from analogy many times in immersion. Argument from analogy was not seen as a scientific schema in previous research (Konstantinidou & Macagno, 2013; Özdem et al., 2013). However, this previous research was held with pre-service teachers who had a good level of background knowledge. Konstantinidou and Macagno (2013) reported that people use argument from cause to effect when they know the content, but use argument from analogy if their knowledge is limited, noting that the use of this scheme is frequently seen in young students. Likewise, the participants in this study experienced the matter and heat and electricity units for the first time, and their knowledge was limited. The students used argument from analogy frequently in immersion orientation to improve their understanding, but they acquired incorrect knowledge frequently when they used argument from analogy. For example, students used an analogy by linking heat insulation and electrical insulation to explain the reason behind electrical insulation, but this analogy caused students to acquire incorrect knowledge such as the distance between particles causing electrical insulation. Moreover, we observed that students used argument from analogy when they constructed the knowledge by working with others. Similarly, Naylor, Keogh, and Downing (2007) reported that students work together when they do not know the content to acquire knowledge. They added that scientists collaborate with others to reach scientific knowledge, noting that collaboration is as important as confrontation in science. Therefore, the fact that the participants collaborated in using argument from analogy could signify that argument from analogy is an important scheme used in middle school science classes.

The Use of Argumentation Schemes in Socio-scientific Orientation

By contrast, the participants used argument from sign, the argument from expert opinion, the argument from example, the argument from correlation to cause, and the argument from consequence more in socio-scientific orientation. This finding was acceptable because Walton's argumentation schemes were derived from arguments used in daily life (Walton et al., 2008) and socio-scientific orientation is closely related to daily life. For example, the students had enough experience to make claims about the energy sources we should use. Students used their inferences and so regularly employed argument from sign. This scheme was also reported as the most used scheme in earlier research (Duschl, 2007; Özdem et al., 2013). Likewise, the students used the information found in evidence cards as an authority and employed argument from expert opinion in the socio-scientific orientation. Similarly, Zemplen (2011) reported that proposing one's own idea is riskier than using expert opinion. Therefore, students use expert opinion in their arguments in order not to pay a social cost. As a result, argument from expert opinion might dominate the weeks when socio-scientific orientation is used.

Walton (1996) reported people use argument from example when they aim to support the main argument. The students consistently used their daily life experiences as examples to support their main arguments. For example, they mentioned specific examples of renewable energy sources to support their main argument that renewable energy sources should be used. Such instances can be seen as evidence that argument from example is a common scheme used in socio-scientific orientation. Likewise, people use argument from correlation to cause when they think there is a cause-effect relationship, even when there is no causation between variables (Walton, 1996). It is meaningful that the argument from correlation to cause showed itself frequently in socio-scientific orientation because the students did not conduct experiments or investigations in socio-scientific orientation and could not test whether a cause-and-effect relationship exists between two variables, with one as a reason and one as result. Therefore, they could not link appropriate causation between variables and they frequently used argument from correlation to cause. Furthermore, the students used argument from consequence in socio-scientific orientation. As topics were directly related to their life, the students could consider the pros and cons of their selection (e.g., the best thermal insulation product in house insulation) in their lives. Therefore, they used argument from consequence in their arguments in socio-scientific orientation.

The Use of Argumentation Schemes in Different Science Units

Second, this study focused on whether the use of argumentation schemes changes in different science units. Therefore, we compared the argumentation schemes results of two science units (weeks 1-2 heat and matter, weeks 5-6 electricity) when immersion orientation was used. The findings suggested that students may tend to use the same schemes in different science units when immersion orientation is adopted. Therefore, we conclude that argumentation schemes do change based on argumentative orientation but do not change in different science units when the same orientation is adopted. A review of previous research found no study comparing students' argumentation schemes in different science units. Previous argumentation studies compared students' argumentation skills in different units (Chen et al., 2016; Foong & Daniel, 2013; Khishfe, 2014). These studies mainly reported that students have limited argumentation skills at the beginning, but they improve their skills over time and can transfer their argumentation skills in different contexts (e.g. science units). Foong and Daniel (2013) explained that students first use their argumentation skills in a familiar context and transfer these skills into their long-term memory. Then, argumentation skills stored in long-term memory are used in new contexts. Similarly, argumentation schemes and related presumptive reasoning skills might have developed in the first unit (matter and heat) where immersion orientation was used and were stored in long-term memory. These skills and schemes were used later in the electricity unit when the same orientation (e.g., immersion) was used.

Furthermore, the frequency of argument from analogy, argument from sign, and argument from evidence to hypothesis increased from the first unit (heat and matter) to the second unit (electricity). Therefore, it could be claimed that the students' use of argumentation schemes and presumptive reasoning increased to some extent in immersion orientation. This improvement in the frequency of some argumentation schemes can be related to students' familiarity with argumentation. The students were not familiar with argumentation at the beginning, so they used the corresponding argumentation schemes used in immersion orientation less when compared with the final weeks of the study (weeks 5-6) when they had become familiar with argumentation.

Lastly, some factors which are selected science topics, students' content knowledge, grade level, culture, and engagement in the argumentation process might affect the results of the study. In this study, we selected heat and matter units and electricity units. The use of argumentation schemes might be different if we used some other units like biology topics. For example; Jonsson (2016) reported that students' use of argumentation skills is different between biology and physics. Likewise, Dawson and Venville (2009) reported that students' use of reasoning is affected by the selected topic. For example; students tend to make rational reasoning when pure science topics are selected, but the use of emotional reasoning increases when a socio-scientific topic is selected (Dawson & Venville, 2009). Similarly, students' content knowledge may matter in their use of argumentation schemes. In line with this, Jonsson (2016) found a significant relationship between 12-year-old students' content knowledge and their argumentation skills. Another factor affecting students' use of argumentation schemes can be their grade level. Accordingly, Duschl (2007) reported that there are more than 25 argumentation schemes, but only 9 of these schemes are suitable for middle school students. In line with this, our participants used 8 argumentation schemes in this study. On the other hand, Özdem et al. (2013) worked with pre-service science teachers and reported these participants who were older than our participants used 20 schemes, so grade level may matter in the use of argumentation schemes. Students' argumentation culture might also affect their use of argumentation schemes. For example; some students might have been more familiar with argumentation before the study; therefore, they might propose more argumentation schemes compared to others who were not familiar with argumentation although we provided more than six weeks of argumentation instruction. Similarly, Foong and Daniel (2013) reported that students who are not familiar with argumentation classes are not ready to propose arguments as they rely on the teacher's ideas as an authority. Students' engagement in the argumentation process might also affect the results. Accordingly, some students engaged in argumentation more than others and this situation might affect the results. In line with this, Zemplen (2011) reported students do not engage in argumentation at the same rate. For example; some of them do not engage because of a lack of reasoning. Similarly, Sampson and Clark (2011) reported students who engaged in argumentation more proposed more oppositional comments and used more rigorous criteria to support and evaluate arguments.

Implications and Limitations

This study provides information about middle school students' argumentation schemes and has implications for teachers and researchers alike. First, the study found that middle school students use different schemes in different argumentative orientations. The participating students mainly used argument from position to know, argument from evidence to hypothesis, and argument from analogy in immersion orientation. Therefore, teachers who implement activities by considering immersion orientation (e.g. Argument-based Inquiry) could prepare learning environments that lead students to use these schemes. For example, teachers could encourage students to ask questions throughout the argumentation. In doing so, they could use argument from position to know more. Then, the students could voice their ideas for answering the questions (argument from position to know), thus generating multiple ideas. These ideas are then evaluated and the argumentation process is maintained. This results in both verbally and cognitively active classes forming. Likewise, teachers can ask students to test their ideas so students can use argument from evidence to hypothesis. Similarly, teachers can use analogies while discussing core ideas and this use of analogy can also help students to use argument from analogy.

Other argumentation schemes, namely, the argument from sign, the argument from example, the argument from expert opinion, the argument from correlation to cause, and the argument from consequence were mainly used in the weeks when socio-scientific orientation was adopted. Depending on the schemes their students use in socio-scientific orientation, teachers can prepare learning environments facilitating students' use of these schemes in socio-scientific orientation. For example, teachers can ask students to make inferences before constructing their arguments and such calls can accelerate students' use of the argument from sign. Likewise, teachers can provide students with videos and visuals during argumentation to help students recall their daily life experiences, which in turn can facilitate students' use of argument from example. Teachers can also actively use textbooks and reliable internet sources in addition to evidence cards in argumentation. Students can use argument from expert opinion by using the information found in multiple sources. However, teachers should prevent the overuse of argument from expert opinion because when this scheme dominates, it inhibits the use of other argumentation schemes and causes poor argumentation. Next, teachers' instruction can also provide activities like concept mapping. In such activities, teachers can provide related topics, concepts, theories, and laws together and ask students to prepare concept maps using this information. The results of students' concept maps might reveal wrong ideas or misconceptions and students' explanations might include argument from correlation to cause. After listening to students' explanations and arguments, teachers can correct students' false knowledge. Lastly, teacher activities can include information about possible advantages and disadvantages of students' potential arguments. Students can formulate the best arguments by analyzing these advantages and disadvantages, and this type of analysis lets students actively use the argument from consequence.

As the study suggested they would, the students used different schemes in different orientations. Using only one of the orientations causes students not to use other schemes, so presumptive reasoning becomes limited. For example, students used argument from evidence to hypothesis in immersion orientation when they produced data, but this scheme was not used in socio-scientific orientation when they did not produce data. Likewise, students used argument from expert opinion in socio-scientific orientation, but this scheme was not used in immersion orientation. According to Wallace (2004), students should combine the data they produced with the already available data. Therefore, researchers should provide students with opportunities that let them merge their own data with the already available data. If they do this, students can form schemes used in both immersion and socio-scientific orientation at the same time.

Next, the study found evidence that students' use of argumentation schemes in immersion orientation does not change depending on the science topic. Researchers can conduct similar research about argumentation schemes in immersion orientation in different science topics. If future research finds results similar to the current study, our findings about schemes used in immersion orientation will be consolidated, and then future research in immersion orientation can be framed based on the common argumentation schemes used in immersion orientation. If other research findings reveal results that contradict our findings; science topic, activity content, grade level, cultural differences, student achievement level, and student engagement in argumentation as possible factors causing this contradiction can be elicited. Either way, our knowledge about the use of argumentation schemes can increase further.

Finally, this study has three limitations. First, we relied on the data obtained from whole-class discussions to portray students' argumentation. However, the study also included pre-activity discussions and small group discussions in addition to whole-class discussions. Therefore, we advise researchers to focus on all discussion phases (e.g., small group, whole-class, and pre-activity). This will throw more light on students' argumentation schemes. Second, the implementation lasted about 6 weeks, which is considered to be relatively short. Future studies can last longer so that students can become more familiar with argumentation and science culture. Such long-term research can provide further information regarding middle school students' use of argumentation schemes. Third, other factors such as grade level, student characteristics, and student achievements might affect our results. For example; students might use different argumentation schemes with different frequencies and percentages when the study is conducted with students from different grade levels. Our findings are limited to the current study's context. Furthermore, this study is a qualitative case study that does not manipulate the variables. Therefore, we can never be certain how other factors affect the students' use of argumentation schemes in a qualitative study. Researchers can conduct experimental research to understand how other factors affect the use of students' argumentation schemes and then they can generalize their findings. On the other hand, this study does not aim to reach some generalization as it is qualitative research. The study portrays students' use of argumentation schemes in our context considering two argumentative orientations and two science units. The ones who have a similar context can benefit from this study.

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Appendix

Argumentation Schemes, Definitions, and Examples

Argumentation Schemes	Description	Example
Argument from sign	This argument is about students' inferences and their endeavors to explain an observation (Duschl, 2007; Walton, 1996).	Interestingly enough, the water temperature decreased less in the metal cup than in the plastic cup. Maybe, the window was open and the wind caused more heat loss in the plastic cup.
Argument from position to know	In this argument, students ask other people questions when they have limited knowledge. (Duschl, 2007).	When you cover the upper surface of the cup with aluminum foil, is it not more difficult to melt fat?
Argument from expert opinion	Students use external sources or authority to support their claim in this argument (Duschl, 2007; Walton, 1996).	I think we can use wood wool on the interior wall as an insulation product because the evidence card provides this information.
Argument from evidence to hypothesis	In this argument, there is a testable hypothesis or prediction. The hypothesis is supported or rejected based on evidence (Duschl, 2007; Walton, 1996).	Our research question was whether the type of wire affects the wire resistance. We hypothesized that the type of wire affects wire resistance.
Argument from analogy	This argument is used when two concrete/abstract things are compared (Walton, 1996).	Similar to sugared water, distilled water does not conduct electricity because of neutrality.
Argument from corelation to cause	Students prefer plausibility rather than possibility in this argument (Duschl, 2007). In this inductive argument, the student observes a positive relation between two variables and thinks that one is the reason for another although there is no direct observation to support this idea (Walton, 1996).	Old trees are vulnerable to environmental factors such as drought and these factors make them sick. These sick and old trees store less CO_2 compared with young trees. Therefore, old trees can be cut down and used as energy sources. (The student ignores the possibility that old trees may not be vulnerable to factors and does not make a right cause-effect relationship between tree age and CO_2 storage)
Argument from example	This argument is used to support a generalization. The current situation is protected when this argument is used (Walton, 1996).	Solar panels should be established in cities that receive plenty of sunlight. For example, Antalya
Argument from consequence	Students consider the potential consequences of decisions in this argument. Decisions with good consequences are supported, and decisions with bad consequences are rejected (Duschl, 2007; Walton, 1996).	We should not use nuclear energy as it is risky and harmful to the environment.