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Observing Primary School Pre-service Teachers' Oral Argumentation in Science Writing Heuristic Implementation

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Abstract

This study provides information on primary school pre-service teachers' (PST) oral argumentation in science writing heuristic (SWH) implementation. Previous research on SWH mainly did not consider primary school PSTs and their oral engagement in the argumentation process. Therefore, this study attempted to understand how primary school PSTs experienced the SWH implementation considering the three aspects of oral argumentation which are cognitive, epistemic, and social. The study lasted six weeks and 34 PST participated in the study. Data were collected using the Assessment of Scientific Argumentation in Class (ASAC) observation protocol. Accordingly, PSTs were observed throughout the implementation and the ASAC protocol was filled each week. Content and constant comparative analysis yielded results about students' oral argumentation. The main findings showed that participants' oral argumentation improved with time. Next, ASAC aspects' observation scores diverged and the scores for cognitive and epistemic aspects were higher than those for social aspects. The findings are discussed and implications are presented considering PST's oral argumentation and the use of ASAC.

Keywords: Oral argumentation, primary school pre-service teachers, science writing heuristics

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Introduction

Argumentation is a practice in which people collectively propose, support, and challenge ideas. People construct and validate knowledge through the argumentation process (Sampson & Clark, 2011). Three types of arguments can be used in argumentation: analytical, rhetorical, and dialectical (Kolsto & Ratcliffe, 2008). In science classes, dialectical argumentation exists. Conversations and informal logic are used during dialectical argumentation and the premises of conversation dominate evidence (Duschl, 2008). As we think that participants focus on whole-class discussion by using evidence, we used dialectical argumentation in this study.

Students can engage in argumentation through writing and talking (Yaman & Hand, 2022). In this study, we specifically paid attention to students' talking, which informs us about their oral argumentation, for the following reasons. First, argumentation is not a cognitive skill or task, it is a collective practice. It is not an end product of the lesson or it is not used in some part of the lesson (Ryu & Sandoval, 2012). As students engage in this practice collectively throughout the lesson by talking, there is a need to understand their oral argumentation process if we want to uncover students' argumentation practice. Second, students can learn through dialog, and students' dialogues should be studied to understand the nature of learning (Chen et al., 2016). Our attempt to understand students' oral argumentation can be valuable in understanding their learning process through argumentation.

According to Grooms et al. (2018), when students engage in argumentation, they also experience three aspects of argumentation which are cognitive, epistemic, and social aspects, and students' performance during oral argumentation can be observed and assessed. In this study, we use Grooms et al.'s (2018) ideas about the assessment of students' oral argumentation and accept cognitive, epistemic, and social aspects as part of students' oral argumentation. Accordingly, the cognitive aspect is about how group members negotiate, whether group members propose reasoned arguments, and whether they are skeptical. Epistemic aspects focus on to what extent the group's argumentation is consistent with scientific culture and norms. For example, epistemic aspects deal with whether group members use evidence and theories or assess the evidence. Lastly, social aspects are associated with how group members interact and discuss with each other, and whether group members respect others' ideas (Grooms et al., 2018).

Argumentation practice provides many advantages for students. For example, it improves students' science achievements (Aydeniz et al., 2012; Çetin et al., 2014; Kingir et al., 2013; Macagno et al., 2015). Aydeniz et al. (2012) explain how argumentation supports scientific achievements as follows: students make reasoning, externalize their ideas, and see the deficiencies of their arguments, and they adjust their ideas by increasing content knowledge. Likewise, students evaluate all ideas that seemed less important before. In this way, they can understand the topic more comprehensively. Similarly, people assist each other during argumentation, low achievers learn from high achievers and high achievers reinforce their understanding (Aydeniz et al., 2012). Argumentation's benefits are not limited to improving science achievements. For example, previous research reported that argumentation improves students' democratic citizenship (Chan & Erduran, 2023; Erduran & Pabuccu, 2015; Joshi, 2016; Orlander Arvola & Lundegard, 2012; Sengul, 2019), attitude (Hong et al., 2013), science literacy (Çetin et al., 2014; Webb et al., 2008), formation of models (Kara & Kingir, 2022; Mendonça & Justi, 2014), scientific epistemology (Erduran & Pabuccu, 2015; Evagorou & Dillon, 2011, Martin & Hand, 2009), critical thinking skills (Macagno et al., 2015), representational competency (Kara & Kingir, 2022; Nichols et al., 2016), argumentation skills' transfer to other disciplines (Chan & Erduran, 2023), and science process skills (Arslan et al., 2023).

Although argumentation presents many benefits to students, teachers rarely prefer to use it (Larrain et al., 2014) and there are mainly two reasons for the non-existence of argumentation in classes. These reasons can be grouped as out-of-class factors and teacher-related factors. Out-of-class factors can be assessment and curricular obligations (Kind et al., 2011), exam-oriented education, over-emphasis on content knowledge, and crowded classes (Jin et al., 2016). Except for these uncontrolled factors, some characteristics of teachers might inhibit the use of argumentation in science classes. Accordingly, have limited or no information and its role (Lin et al., 2017; Martin-Gamez & Erduran, 2018). Likewise, teachers fail to use argumentation for teaching (Dawson & Carson, 2017; Lin et al., 2017; Martin-Gamez & Erduran, 2018). As a result, students can not become familiar with argumentation and

construct complex arguments including qualifiers and rebuttals when argumentation is not used in class. On the other hand, Evagorou and Dillon (2011) reported teachers can improve both their understanding of argumentation and argumentation teaching through instruction.

Science Writing Heuristics (SWH)

One of the argumentation approaches that supports teaching and learning is science writing heuristics (SWH). SWH is an example of an argument-based inquiry approach consistent with the immersive approach (Cavagnetto, 2010). The immersive approach uses the argument as an epistemic tool and provides learning. Students immerse in epistemic practice and learn science content (Hand et al., 2019).

SWH frames on question, claim, and evidence. SWH aims students learn content knowledge through constructing and criticizing arguments (Hand et al., 2019). According to Hand et al. (2019), SWH has three phases which are the development of the underpinning epistemic framework of science (e.g., development of scientific practice), an argument phase (e.g., learning content), and a summary writing phase (e.g., teaching content to an audience).

Previous research showed that some argument-based inquiry (ABI) approaches suggested higher student learning benefits than other approaches (Weiss et al., 2022). For example, Weiss et al. (2022) compared 16 immersive ABI approaches and reported that SWH is better than other ABI approaches in terms of student actions, teacher actions, and generative opportunities. Similarly, Hand et al. (2021) reported that SWH improves students' content knowledge by closing the achievement gap, critical thinking skills, scientific reasoning, process skills, and representational skills more than traditional teaching in their systematic review. Furthermore, Hand et al. (2019) claimed that SWH is a useful approach starting from the early childhood level. As a result, we decided to use SWH to improve participants' engagement in oral argumentation.

Primary School Pre-service Teacher Education

Previous research reported that human beings start engaging in argumentation practice from the early years of their life (Chen, 2019; Lawson, 2003; Perry & Dockett, 1998; Ryu & Sandoval, 2012). For example; Ryu and Sandoval (2012) asserted that argumentation improves students' cognitive development at the elementary level, and students can learn argumentation practice and fundamental epistemic practices in these grades. However, Chen et al. (2016) reported students do not have enough opportunities to experience argumentation at the early elementary level (Grades 1-3). One of the reasons that primary school students (K-4) can not experience argumentation might be the content of the primary school pre-service teacher education programs (i.e., PST programs). Accordingly, PST programs do not include argumentation in their science courses, and therefore PST can not understand argumentation. Similarly, PST can not teach argumentation in their future classes (Chen et al., 2020; Martin-Gamez & Erduran, 2018; Şahin-Kalyon & Özdem-Yılmaz, 2023; Yaman & Hand, 2022). For example; Martin-Gamez and Erduran (2018) reported primary school PST had limited argumentation understanding and argumentation strategies for teaching. Researchers also reported that PST ignored the rebuttals which are signs of high-quality arguments. Likewise, Yaman and Hand (2022) reported that teachers teach as how they are taught. If their PST programs do not offer argumentation, these teachers will not use argumentation in their future careers. Therefore, PST programs could include argument-based inquiry approaches so that PST can use argumentation in their future class (Yaman, 2018; Yaman & Hand, 2022). In line with this, Aguirre-Mendez et al. (2020) reported non-science majors' science laboratory courses are based on memorizing facts, but these courses should give up memorization and focus on improving critical thinking skills. Therefore, science laboratories for non-science majors should embrace the SWH approach to improve critical thinking skills. Considering the above-mentioned needs, the current study focuses on improving primary school PST's oral argumentation via the SWH approach. In this way, we assume that pre-service teachers experience and understand argumentation, and they will use argumentation through SWH in their future primary school classes. Similarly, their future students who experience SWH may learn more.

Theoretical Framework

Kind et al. (2011) reported that schools use empirical logical ideas and argumentation is not integrated at school laboratories. According to these empirical ideas, traditional science laboratories are used,

there is one scientific method, science is not complex, and experiment results in absolute correct knowledge (Kind et al., 2011). However, interaction among individuals provides learning according to social constructivism. Tools, symbols, and language used in this interaction construct the knowledge. Students use scientific knowledge and validate it in the laboratory through argumentation. They also learn how science is done in this process (Walker & Sampson, 2013). Similarly, students become members of the scientific community and understand concepts, language, representations, and practices of science culture during argumentation in the laboratory (Sampson & Clark, 2011). In line with this explanation, social constructivism was used as the theoretical framework in the current study consistent with previous research (e.g., Walker & Sampson, 2013).

Literature Review

Previous research examined students' oral argumentation at different grade levels including early elementary level (Chen et al., 2016), elementary level (Berland & Lee, 2012, Chen et al., 2016, Chen & Qiao, 2020; Chen & Techawitthayachinda, 2021; Kim & Hand, 2015), middle school level (Duschl, 2008), highschool level (Sampson & Clark, 2011; Grooms et al., 2018), and pre-service teacher education level (Emig et al., 2014; Mete, 2023; Walker & Sampson, 2013; Yaman & Hand, 2022; 2024). For example; Chen et al. (2016) examined the role of teacher's questions during SWH in the early elementary level (K-3) and reported that the teacher's role was dispenser at the beginning of the study and students' answers corresponded to a low cognitive level according to Bloom taxonomy. Researchers reported that students ' answers improved from low cognitive level to high when the teacher's role transformed into moderator, coach, and participant. Likewise, ownership of ideas and activities is passed from the teacher to the students over time which is evidence for the improvement of students' engagement in argumentation.

In another study conducted with elementary and middle school students, Chen and Techawitthayachinda (2021) examined the strategies that teachers use to manage uncertainty during argumentation. Researchers reported that teachers propose a problem or emphasize inconsistent data patterns to raise uncertainty when there is no argumentation in class. To maintain uncertainty; researchers reported that teacher selects similar and different ideas to be discussed, asks students to criticize each other, and criticizes students' ideas for further thinking. Researchers added that when it is time to reduce and resolve uncertainty; the teacher assists students' collective construction of the problem's solution and uses students' prior knowledge to construct a holistic knowledge system.

Next, Sampson and Clark (2011) examined high school students' oral argumentation and reported that students producing high-quality arguments (i.e., high performers) mentioned many more core ideas and discussed them further. Likewise, high performers used oppositional discourse more than low performers and they could elaborate their discussion. Similarly, while high performers used rigorous criteria (e.g., consistency between claim and evidence) to assess arguments, low performers used informal criteria (e.g., consistency between claim and prior knowledge). Next, high performers used data for both the construction and criticism of their arguments, but low performers used data only for the construction of their arguments.

Researchers also examined PST's oral argumentation. For example; Yaman and Hand (2022) investigated pre-service chemistry teachers' oral argumentation in SWH instruction lasting 28 weeks. Researchers reported PST's argument and representation quality improved over time. They found a positive and significant relationship between oral argumentation and oral representation and added that written and oral argumentation complement each other as both forms of argumentation are used to convince others.

Although there were many studies conducted with various grade levels (e.g., pre-service teacher education) examining participants' oral argumentation, we found only two studies examining all three aspects of oral argumentation (Grooms et al., 2018; Walker and Sampson, 2013). Walker and Sampson (2013) studied PST and used the assessment of scientific argumentation in class (ASAC) observation protocol to understand PST's oral argumentation. Researchers found that participants' oral argumentation quality changed from one topic to another. While PST focused on argument generation at the beginning, they focused on argument evaluation later. Researchers also reported that participants could not integrate different data and construct high-quality arguments. In another study, Grooms et al.

(2018) focused on high school students' oral argumentation and reported that students engaged in argumentation better over time when they knew the content. Researchers reported epistemic and social aspects improved in familiar tasks, but the cognitive aspects did not. On the other hand, only the epistemic aspect improved in unfamiliar tasks. Researchers also found students did not evaluate claims and use scientific criteria when the epistemic aspect of argumentation was low. Similarly, students did not discuss new ideas when the social aspect of argumentation was low. It was also reported reasoned arguments were produced when the cognitive aspect was high.

Significance of the Study

Previous research reported that although there are many argumentation studies held with pre-service teachers, there are a limited number of studies conducted with primary school PST (Şahin-Kalyon & Özdem-Yılmaz, 2023). By examining primary school PST's oral argumentation, this study adds a contribution to primary school PST's science education literature.

Aguirre-Mendez et al. (2020) added that most of the argumentation studies are held with science majors, but there are limited studies held with non-science majors. However, most of the public is graduates of non-science major departments. Science courses for non-science majors should be designed to improve their science literacy (Aguirre-Mendez et al., 2020). In our case, primary school PSTs were also non-science majors and we designed a laboratory course based on SWH for them. This study may address the needs of non-science majors by offering science laboratory courses for primary school PST and non-science majors can improve their science literacy.

Another significance of the study is the aspects of oral argumentation. Regarding the aspects of oral argumentation, Sampson and Clark (2008) reported oral argumentation includes epistemic, cognitive, and social aspects of argumentation, but very few studies focused on all these three aspects together. In line with this, our literature review showed only two studies focused on these three aspects (Grooms et al., 2018; Walker and Sampson, 2013), and none of these studies were conducted with primary school PST. As a unique significance, this study focuses on primary school PST's oral argumentation considering three aspects (e.g. epistemic) to capture primary school PST's oral argumentation holistically which was ignored in previous research.

To sum up, this study aims to assess primary school PST's oral argumentation by considering three aspects of oral argumentation (e.g. cognitive) using the SWH approach. Therefore; the study has one research question: "How is primary school pre-service teachers' oral argumentation performance regarding cognitive, epistemic, and social aspects of argumentation during SWH implementation?" In this study, we specifically focused on primary school pre-service teachers' engagement in the argumentation process by using the ASAC observation protocol that includes cognitive, epistemic, and social aspects. In this way, we observed PSTs' oral argumentation in six weeks and tried to uncover both the nature of their oral argumentation in a SWH implementation and observe what changes in this process.

Method

Research Design

This qualitative study is an example of a case study that is the study of an issue investigated through a case or cases within a bounded system (Creswell, 2007). In case study research, the case is determined based on an issue (McMillan & Schumacher, 2001). The issue here is our limited understanding of primary school PST's oral argumentation including its aspects (e.g., epistemic). This SWH study was carried out to improve our understanding of primary school PST's oral argumentation. In other words, this SWH research attempted to solve the issue. Therefore, SWH implementation was the case in the current study. As each case has its boundaries (Creswell, 2007), this SWH implementation had its boundaries. Accordingly, the SWH implementation lasted six weeks. Activities unique to this SWH implementation were creating research questions, designing investigations, carrying out investigations, proposing arguments, small group discussions, and whole-class discussions (Kingir et al., 2013). During whole class discussion, the groups are expected to present their investigation reports, their claims, and whole-class engage in the oral argumentation process. As class engages in oral argumentation in whole-class discussion, we think that it is valuable to focus on whole-class discussion to collect data. Therefore, we specifically focused on whole-class discussions.

These activities were carried out starting from the first week and followed each week until the end of the study. Lastly, two groups of PST participated in the study, and each group was accepted as a sub-unit.

Participants

Two groups of PST participated in the study. There were 34 participants in the study. Group 1 included 15 students, and Group 2 had 19 students. All students were female in group 1, 3 of whom were male in group 2. All students were sophomore primary school pre-service teachers. The students were not good at science because they did not get many science courses in their high school. Likewise, their undergraduate department program did not offer so many science courses to develop their scientific knowledge. 'Fundamental science in primary school course' was the only science-related course students took before the study. So, students were not experienced in science and were labeled as non-science majors. The study was conducted in a private university located in Ankara, Türkiye. The primary school department's laboratory was used for research. Students voluntarily formed their groups and each group included 3-4 students. Group members did not change throughout the study.

Procedure

The study was conducted in Laboratory Applications in Science lesson prepared for primary school PSTs. Two sections (group 1 and group 2) participated in the research and the same instructor implemented the SWH and other activities. The course instructor was familiar with SWH and argumentation and implemented SWH in previous years, so the instructor was not trained for SWH.

SWH implementation was not directly implemented because primary school PSTs were unfamiliar with science and SWH. Therefore, the groups were prepared for scientific inquiry and argumentation in the first six weeks. Accordingly, laboratory materials were introduced in the first week. Various methods of data collection and analysis were focused on in the second and third weeks. PSTs conducted activities for basic process skills (e.g., measurement) in the fourth week. PSTs carried out experiments to understand integrated process skills (e.g., controlling variables) in the fifth week. In the sixth week, argumentation and SWH were introduced to participants, and the course instructor explained what was expected from them in this process. SWH implementation started in the seventh week and lasted six weeks. Each week's activity lasted four hours for each group. In total, each group experienced SWH 24 hours (6 weeks x 4 hours). All activities were created by the researchers.

In line with the SWH approach, each group found a research question about that week's big idea. Then, they prepared their research design and discussed it with the rest of the group to understand whether their research question was testable or not. Then, groups tested their investigation and reached their claims by using data as evidence for their claims. Next, groups presented their claim to the rest of the class in whole-class discussions and defended their arguments while others' criticized their claims. After all groups' arguments were discussed and PSTs negotiated on arguments, PSTs compared their ideas with secondhand data which are the course instructor, reliable internet sources, and science books. Negotiations with second-hand data let them reach a final argument that was the answer to their research question.

PSTs engaged in SWH implementation in six different activities. When we prepared the activities, we benefitted from our previous SWH experiences. Accordingly, we carried out SWH implementations with other participants except primary school PSTs in the past and we saw that these activities were ideal for the successful implementation of SWH. Therefore, the activities given in Table 1 were selected for the study. In the first week of SWH, the activity was about the electrical conductivity of liquids. In the second week, PSTs tried to solve the mystery of a magic box that was prepared based on the principles of liquid and gas pressure, gravity, and cohesive forces. The third week's activity was about heat transfer. In the fourth week, PSTs investigated the factors affecting the rate of solubility. Next week, PSTs tried to construct the highest and most durable towers using play doughs and toothpicks. In the last week, the groups visited a lake as a field trip and focused on the factors affecting plant populations in a specific area. The procedure is summarized in Table 1.

Table 1.
Summary of the Procedure

Weeks	Course Content
Week 1	Course Introduction and Laboratory Materials
Week 2	Different methods of data collection and analysis
Week 3	Different methods of data collection and analysis
Week 4	Basic Process Skills
Week 5	Integrated Process Skills
Week 6	Introduction of Argumentation and SWH
Week 7	Electrical Conductivity of Liquids (First SWH Activity)
Week 8	Magic Box (Second SWH Activity)
Week 9	Heat Transfer (Third SWH Activity)
Week 10	The Factors Affecting the Rate of Solubility (Fourth SWH Activity)
Week 11	Construction of Tower (Fifth SWH Activity)
Week 12	The Factors Affecting Plant Populations in a Specific Area (Sixth SWH Activity)

Data Collection

Data Collection Tool: ASAC Protocole

Sampson et al. (2012) reported examining whole argumentation in class and analyzing are is very difficult processes. For example, if we focus on the number of evidence, we ignore reasoning, student communication, criteria to evaluate arguments, and the use of materials. Sampson et al., (2012) claimed that there was a need for an instrument to assess all aspects of argumentation, and they prepared the Assessment of Scientific Argumentation in the Classroom (ASAC) observation protocol. Sampson et al. (2012) claimed researchers can understand the quality of argumentation in class, and the change in the quality of argumentation, and compare different approaches' effects on argumentation quality using ASAC. ASAC observation protocol is in English, and as observers, we filled the ASAC protocol throughout the study. How we used the ASAC protocol is explained in the data collection process.

In line with this, we used ASAC to understand primary school PST's oral argumentation in SWH implementation lasting six weeks.

ASAC is context and topic-free and was prepared to assess observable things in an argumentation class (Sampson et al., 2012). The instrument is 4 point Likert type and the items are scored 0 when they are never observed, and the rating score increases up to 3 depending on how often the item's expectation is met. ASAC has 3 constructs and includes 19 items. The maximum score for the whole scale is 57 (3 x 19). The first is the cognitive aspect including 7 items (e.g., Do participants focus on the solution of the problem?). The second is the epistemic aspect which also includes 7 items (e.g., Do participants use evidence?). The third is the social aspect that includes 5 items (e..g, Do participants respect each other?). The researchers found 97 % for the inter-rater agreement and correlated ASAC results with Toulmin Argumentation Pattern (TAP) results to support criterion validity, and found a correlation of 0.96. Furthermore, researchers got expert opinions from field experts twice to support the translational validity of the instrument (Sampson et al., 2012).

Data Collection Process

We focused on the whole class discussions to observe PSTs' oral argumentation. The authors sat at the back of the classroom and took notes on the ASAC protocol during whole class discussions for each group throughout the study. While we were taking notes, we did not interact with each other, and we scored ASAC items separately based on the field notes. After scoring each item, we wrote our justification for each scoring. After each lesson, we compared our scoring for each item. Then, we reached a consensus for disputed scorings. Inter-rater reliability was 87 % for the cognitive aspect, 91% for the epistemic aspect, and 90 % for the social aspect. In total, inter-rater reliability was found 88 % for ASAC instrument scores.

Data Analysis

This study attempts to understand primary school PSTs' oral argumentation and ASAC observation protocol was used throughout the study to reveal participants' oral argumentation. After ASAC protocols were filled, collected data was analyzed by two consecutive analyses which are content analysis and constant comparative analysis.

Content Analysis

Researchers took field notes during whole class discussions for each group and each week. Then, the content of these observations was used for scoring 19 ASAC items separately. For example, if researchers' field notes support expected behavior for that item, the content of the field notes was used as evidence for high scoring in that item. In this way, we converted the qualitative data (i.e., the content of the field notes) into quantitative data. Then, we summed up item scores to get the total ASAC score, total cognitive aspect score, total epistemic aspect score, and total social aspect score for each group and each week. In this way, we could identify the oral argumentation performance of each group for each week regarding total oral argumentation and individual aspects (e.g., cognitive aspect) and we got line graphs showing groups' oral argumentation performance throughout the study.

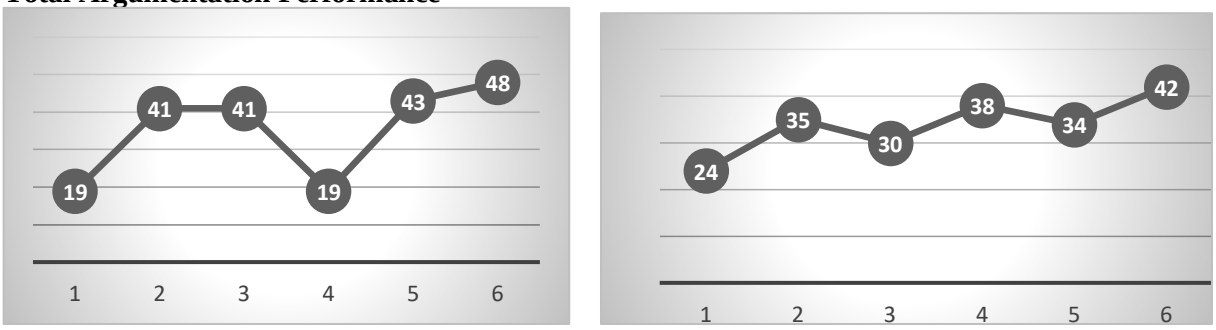
Constant Comparative Analysis

After we got graphs representing their oral argumentation performance and individual aspects for the two groups, we constantly compared these two groups' graphs in terms of total oral argumentation performance and different aspects of oral argumentation (e.g., cognitive aspect). Similar patterns in the two groups' graphs obtained from constant comparison analysis yielded assertions about PSTs' oral argumentation. These assertions are answers to the research question.

Findings

This study attempted to answer the research question "How is primary school pre-service teachers' oral argumentation performance regarding cognitive, epistemic, and social aspects of argumentation during SWH implementation?" To answer this question, the ASAC observation protocol was used and two groups of PSTs participated in the study. Examination of groups' ASAC scores assisted us in creating line graphs for the total argumentation performance, cognitive aspects, epistemic aspects, and social aspects.

Total Argumentation Performance



Group 1 Group 2

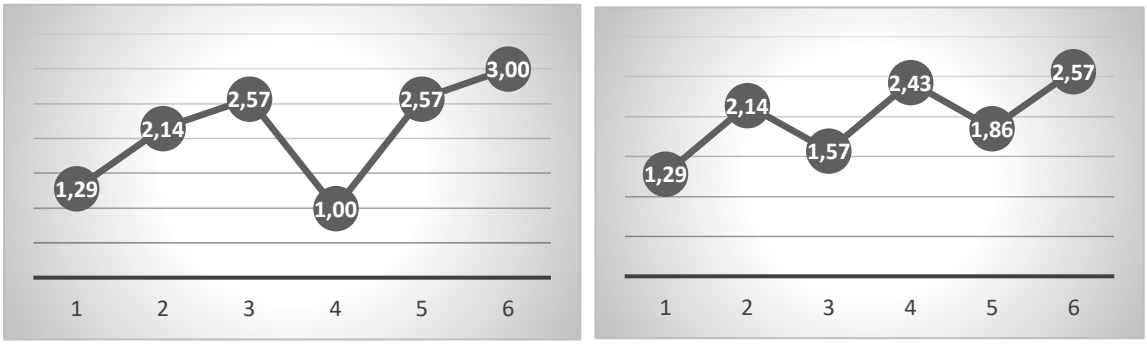
Figure 1. Overall Argumentation Performance

The two groups' total argumentation performances are presented in Figure 1. The maximum score the groups can get is 57 for the ASAC observation protocol. Group 1's observation score ranged between 19 and 48, and the mean score was 35.17. Accordingly, group 1 performed best in the 6th week (the factors affecting plant population) as they got 48 points over 57. On the other hand, group 1 performance was highly low in the 1st (electrical conductivity in liquids) and 4th (factors affecting the rate of solubility) weeks, and group 1 got 19 points in these weeks.

Group 2's total oral argumentation observation score ranged between 24 and 42, their mean was 33.83. Similar to group 1, group 2 performed best in the last week (the factors affecting plant population)

taking 42 points over 57. Group 2 performance was low in the first week (electrical conductivity in liquids) and their score was 24.

Cognitive Aspects



Group 1 Group 2

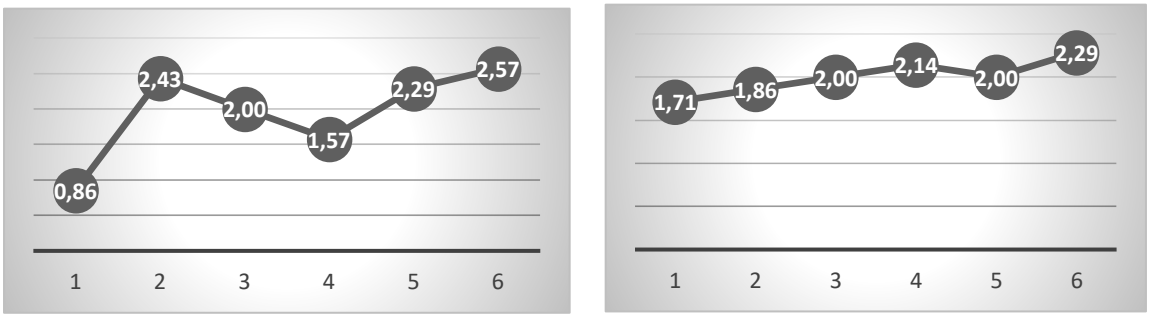
Figure 2. Groups' Cognitive Aspects' Results

After total oral argumentation scores, we specifically focused on PSTs' aspects of oral argumentation in SWH implementation. In the ASAC, the number of items for different aspects is different. For example, cognitive and epistemic aspects have 7 items, but social aspects have 5 items. Therefore, we focused on the mean scores to compare PSTs' performance in different aspects of oral argumentation. As the maximum score for each item was 3, the maximum mean score was 3 too for each aspect of oral argumentation.

The cognitive aspect is about how group members negotiate, whether group members propose reasoned arguments, and whether they are skeptical (Grooms et al., 2018). Weekly mean scores for oral argumentation's cognitive aspects are presented in Figure 2 for each group. Group 1's cognitive aspects' mean score was 2.10 over 3, and the scores ranged from 1.00 to 3.00. Group 1's cognitive aspect reached the highest level in the last week (the factors affecting plant population) and it was 3.00; on the other hand, the group's cognitive aspects' result was the least (M=1.00) in the fourth week (factors affecting the rate of solubility).

Similar to group 1, group 2's cognitive aspects' mean score was 1.98 over 3, and the range was between 1.29 and 2.57. In the last week, group 2's cognitive aspects score reached 2.57 which was the highest for this group. The lowest cognitive aspects score group 2 got was 1.29 and this score was obtained in the first week (electrical conductivity in liquids).

Epistemic Aspects



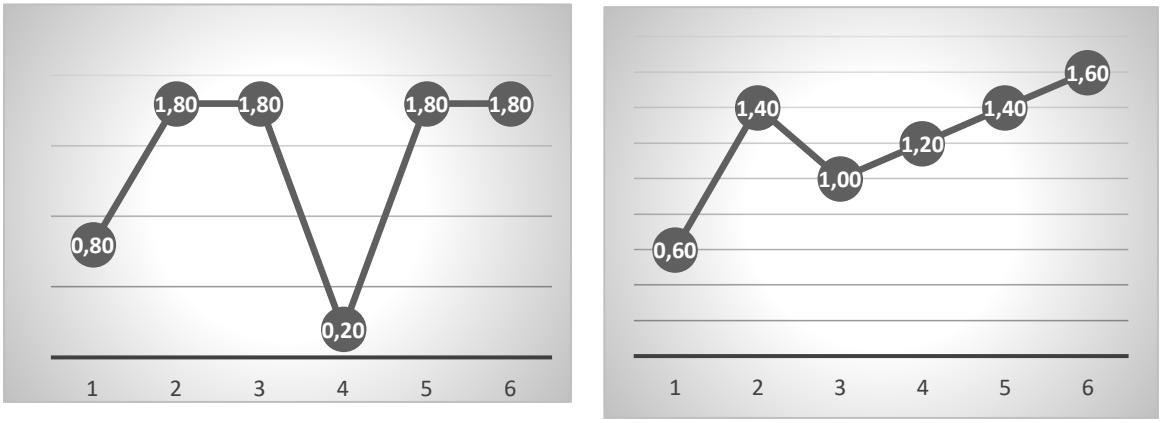
Group 1 Group 2

Figure 3. Groups' Epistemic Aspects' Results

Epistemic aspects focus on to what extent the group's argumentation is consistent with scientific culture and norms (Grooms et al., 2018). Figure 3 shows that group 1 improved their epistemic aspects' score from 0.86 to 2.57 over time. The mean score for group 1's epistemic aspects was 1.95 over 3. While the epistemic aspects' score was the lowest in the first week (M=0.86), it was highest in the last week (M=2.57).

Similar to Group 1, group 2's epistemic aspects score improved, but there were fewer fluctuations in Group 2 (see Figure 3). Group 2's epistemic aspects score increased from 1.71 to 2.29. The mean score was 2.00 over 3. The group performed best in the last week (M=2.29), but their epistemic aspects' performance was relatively low in the first week (M=1.71).

Social Aspects



Group 1 Group 2

Figure 4. Groups' Social Aspects' Results

Social aspects are associated with how group members interact and discuss with each other, and whether group members respect others' ideas (Grooms et al., 2018). The performance of the social aspects of the groups was lower compared with the other two aspects (e.g., cognitive) throughout the study, but the social aspects performance still increased for both groups (see Figure 4). Accordingly, group 1's social aspects' mean score was 1.37 and it ranged from 0.20 to 1.80. In the fourth week (factors affecting the rate of solubility), it can be claimed that PSTs nearly did not engage in argumentation (M=0.20). On the other hand, the group's social aspect performance was relatively higher in other weeks (M=1.80) except week 1.

Similar to group 1, group 2's social aspect's mean score was low (M=1.20 over 3). The scores ranged between 0.60 and 1.60. The group's social aspects' performance was the lowest in the first week

(electrical conductivity in liquids) (M=0.60), but it gradually increased and reached 1.60 in the last week (the factors affecting plant population).

Depending on these findings, we claimed two assertions about primary school PSTs' oral argumentation performance in this SWH implementation lasting 6 weeks.

Assertion 1: Participants' oral argumentation improved over time.
The main argument for the findings is there is an improvement in participants' oral argumentation from the first week to the last week in general (see figures). Accordingly, group 1's total oral argumentation score increased from 19 to 48, and group 2's total oral argumentation increased from 24 to 42 (figure 1). A similar trend was also observed in aspects of oral argumentation. For example; cognitive aspects' weekly mean score increased from 1.29 to 3.00 for group 1 and from 1.29 to 2.57 for group 2 (figure 2). Likewise, epistemic aspects' weekly mean score increased from 0.86 to 2.57 for group 1 and from 1.71 to 2.29 for group 2 (figure 3). Similarly, the weekly mean score for social aspects increased from 0.80 to 1.80 for group 1 and 0.60 to 1.60 for group 2. In conclusion, it can be claimed that both participants' total oral argumentation and its aspects' scores improved throughout the study.

Assertion 2: ASAC aspects' observation scores diverged and the scores for cognitive and epistemic aspects were higher than those for social aspects.
When we examined Figures 2, 3, and 4; we noticed that participants' performance was not the same in different aspects of oral argumentation although all of them increased. Accordingly, the cognitive and epistemic aspects' scores were higher than the social aspects' scores (see Figure 2-3-4). For example, the groups' last week performance was at a high level (more than 2.00 over 3.00) for cognitive and epistemic aspects, but both groups' social aspects performance was medium-high (1.80 for group 1 and 1.60 for group 2) in the same week.

Similarly, both groups developed their cognitive and epistemic aspects' scores more than their social aspects' scores in general. Accordingly, group 1 improved their cognitive aspects' score by 1.71 points, and group 2 improved by 1.28 points (figure 2). Likewise, group 1 improved their epistemic aspects' score by 1.71 points (figure 3). On the other hand, groups improved their social aspects' scores by only 1.00 points (figure 4) although the social aspects' starting score was lower compared with their cognitive and epistemic aspects' initial scores.

Discussion, Conclusion, and Suggestions

Discussion of the study is shaped based on two assertions presented in the findings section. Hence, we first discuss the development of primary school PSTs' oral argumentation performance in this SWH study. Then, we discuss the divergence of oral argumentation aspects and attempt to explain why PSTs' performance of cognitive and epistemic aspects was higher than their social aspects' performance.

Improvement of Oral Argumentation

Primary school PSTs improved their oral argumentation over time depending on ASAC observation results. Similarly, Chen et al. (2016) reported that 5th-grade students improved their oral argumentation through SWH. Accordingly, students focused on the construction of arguments by ignoring others' ideas and they did not criticize others impeding oral argumentation in the initial weeks. However, students started listening to others' ideas and they challenged, rejected, and supported them in later weeks, so their oral argumentation improved (Chen et al., 2016). Similarly, in our research, participants avoided attacking others' ideas about the electrical conductivity of the liquids (week 1) although their results were different from other groups. They just talked about their claims and did not share their ideas about others' claims. On the other hand, when it comes to last week that the factors affecting the plant population, all groups criticized each other, they actively engaged in whole-class discussions, and students reported they had headaches at the end of the lesson as they thought too much during the lesson. A similar trend was also observed in Walker and Sampson's (2013) study. Walker and Sampson (2013) reported that PSTs focused on argument generation in the initial weeks, but they focused on both argument generation and argument evaluation in the following weeks.

Walker and Sampson (2013) explained students' initial low argumentation performance considering class culture. Accordingly, PSTs accepted the instructor as an epistemic authority and asked the instructor who was right when they contradicted others. In other words, PSTs focused on reaching correct knowledge and ignored the argumentation process in these initial weeks (Walker & Sampson, 2013). Similarly, Lin and Mintzes (2010) reported it is very difficult to improve students' argumentation skills in authoritarian cultures. The same situation can be also true for the current study because PSTs tried to verify their knowledge in the initial weeks by asking questions to the course instructor instead of engaging in oral argumentation. Walker and Sampson (2013) added that PSTs started to compare faults in the data collection process after two weeks, and they started changing their ideas and their reasoning started to increase. Similarly, oral argumentation scores started increasing after the second week in this study.

We think that the science writing heuristics (SWH) approach as a scaffolding facilitated PSTs' oral argumentation process. For example, PSTs used writing and talking simultaneously as an aspect of SWH. Chen et al. (2016) explain the benefits of the simultaneous use of writing and talking as such: when participants integrate writing and talking, they construct the knowledge using texts. Participants also support their ideas using representations in their writing. Similarly, the integration of talk and representations forms deep thinking. Faulty ideas and missing parts of the models in the written texts are also criticized and original ideas change faster when writing and talking are simultaneously used in SWH (Chen et al., 2016).

Likewise, prompt questions found in the SWH student template could facilitate PSTs' oral argumentation. For example, they could write their evidence, claim, data, and others' ideas in the SWH student template. By using their SWH student reports, they might easily engage in oral argumentation. However, researchers should be careful with the scaffolding issue. The scaffolding issue happens if one of the scaffolding aspects (problematizing or structuring content) is over-emphasized, the scaffold does not work, and participants can not benefit from scaffolding for better argumentation (Emig et al., 2014). This issue can be also true for this study. For example, participants would like to explain their arguments in their way, but the prompt questions we provide might inhibit the exhibition of some of their valuable ideas which can not be captured by prompt questions.

Similarly, Enderle et al. (2022) reported prompt questions to cause formal structures while they assist students' learning. Such formal structures may decrease student discourse and move the lesson from student-centered to teacher-centered because support tools may decrease student autonomy, and if these tools are not used correctly, pseudo-argumentation can be done in class (Enderle et al., 2022). Inappropriate use of scaffolding was also seen in group 1 in the fourth week and this erroneous scaffolding resulted in the low performance of PST's oral argumentation in that week. The fourth week's topic was 'The Factors Affecting the Rate of Solubility' and participants were not knowledgeable in this topic in group 1. The course instructor provided an example of a research question about the topic and assisted PSTs with how they could conduct their experiment. Accordingly, the instructor said that factors like mixing the solution, changing heat, or the size of particles might affect the rate of solubility and said that the group's research question could be 'What is the effect of the size of particles in the rate of solubility?'. Furthermore, the instructor assisted participants in how they could design their experiment considering this research question. In other words, the course instructor improved structuring and decreased problematizing the content. As a result, group 1 did not engage in oral argumentation much in week 4.

Furthermore, this study showed that PSTs' oral argumentation does not improve linearly, and there are some fluctuations as seen in Figure 1. For example; the performance of the second group decreased from week 4 to week 5 or the performance of the first group was the same in the second and third weeks. We think that the context and argumentation relationship explains why oral argumentation does not develop in some weeks. According to Cavagnetto and Kurtz (2016), students are not deficient in making argumentative reasoning, but they do not know when they activate their reasoning and the context determines when students activate their reasoning. If contextual cue is provided, students' performance improves. In this study, some activities can be more demanding than others for students, and PSTs might not activate their reasoning in those weeks, so their oral argumentation could be limited. Similarly, Walker and Sampson (2013) reported that PSTs could not improve their oral

argumentation in the last week of the study because PSTs did not understand the task and materials. Researchers added that if PSTs use materials they know very well, their argumentation performance can increase.

Cognitive, Epistemic, and Social Aspects of Argumentation

In this study, we observed the development of students' oral argumentation in a six-week-long SWH study. When we specifically analyzed three aspects of oral argumentation, we observed that the cognitive and epistemic aspects' scores were higher than the social aspects at the initial observations. Throughout the study, all three aspects' scores improved, but the final scores of social aspects were still lower than the other two oral argumentation aspects.

Similar to this study, Grooms et al. (2018) carried out an argument-based inquiry study using ADI (Argument-driven Inquiry) with high school students. Researchers reported that participants' oral argumentation's cognitive aspect did not improve in their study. They also added that participants engaged in scientific argumentation as they did in real-life argumentation and participants did not change their thought system (Grooms et al., 2018). On the other hand, participants of this study improved their oral argumentation's cognitive aspects. This can be related to two factors. First, our participants were PSTs and older than Grooms et al.'s (2018) participants. Because of their age, our participants might adapt using reasoned claims and examining alternative ideas, so their oral argumentation's cognitive aspects increased. Second, the treatment differences might cause a difference between the two studies considering the cognitive aspect. While we used SWH, the previous research used ADI. The SWH approach might be better than ADI for developing cognitive aspects of oral argumentation. In line with this, when comparing different ABI approaches in terms of student actions, teacher actions, and generative opportunities, Weiss et al. (2022) reported the superiority of SWH over ADI. Likewise, Hand et al. (2021) reported that SWH improves critical thinking skills (CTS) and scientific reasoning more than alternative treatments. The participants of this study might have improved their CTS and scientific reasoning due to SWH, and they might exhibit their developing reasoning and skills as evidence for improvement of cognitive aspect.

Next, oral argumentation's epistemic aspects improved in this study consistent with Grooms et al. (2018). Grooms et al. (2018) reported epistemic aspects improve regardless of participants' familiarity with the topic when they get argument-based inquiry (ABI) treatment. This means that when participants engage in ABI, they learn the rules of scientific argumentation (e.g., what counts as valid evidence in scientific argumentation) (Grooms et al., 2018). Grooms et al. (2018) also added participants can transfer their epistemic aspect level from a familiar context to an unfamiliar one. Similarly, participants of this study seem to transfer their developing epistemic aspects level to new contexts (physics, chemistry, biology) during the study. Development of the epistemic aspect through SWH is also consistent with Ryu and Sandoval's (2012) ideas. Accordingly, Ryu and Sandoval (2012) reported that participants construct the scientific criteria when they learn science through practice and there are no criteria imposed on participants. In this way, participants learn the scientific norms and criteria. In line with this, we think that the SWH approach provides participants opportunities for science practices which are designing experiments, data collection, small group discussions, whole class discussions, and negotiations with experts. When participants engaged in these practices, their oral argumentation's epistemic practice might have improved. Similarly, Hand et al. (2004) found that students learn argument structures better and connect research questions, claims, and evidence successfully when they get SWH implementation.

Although participants' cognitive and epistemic aspects of oral argumentation were relatively high throughout the study, the social aspects were lower at the beginning and end than the other two aspects. Therefore, we think that social aspects are the problematic part of this study. Groom et al.'s (2018) findings were more complicated than current research. The researchers reported participants improved social aspects in the familiar context, but they did not engage in whole class discussion and they accepted the claims without criticism when they were unfamiliar with the topic (Grooms et al., 2018). As participants of this study were primary school PSTs, they had limited content knowledge (Şahin-Kalyon & Özdem-Yılmaz, 2023) which might make them unfamiliar with most science topics and this might explain why their oral argumentation's social aspects scores were less. Another reason for lower social aspect scores can be related to the duration of the treatment. This study lasted six

weeks and social aspects improved from low level to the medium-high for both groups in this period. If the study had lasted more, social aspects scores might have improved further and reached the other two aspects' levels. If this explanation is correct, we may infer that improvement of social aspects requires more time than cognitive and epistemic aspects.

Implications

The study has significance for primary school pre-service teacher education programs, course instructors from primary education departments, and researchers. To begin with, the content of this laboratory course is new for primary school PST programs. Accordingly, we designed a course that prepares primary school PSTs for scientific inquiry in the first six weeks and oral argumentation using SWH in the last six weeks. Primary school PST programs can use our design in their science laboratory courses to increase PST's argumentation understanding and teaching. We think that laboratory courses for primary school PST should not start with SWH. Instead, they should start with warm-up weeks for SWH that make students familiar with the scientific inquiry because these students have no specialization in science.

The study has two implications for course instructors teaching in primary school PST programs. First, we advise course instructors to use SWH in primary school PST laboratory courses because SWH implementation supports' PST's oral argumentation and its aspects. Second, course instructors should be careful with scaffolding because over-structuring the scaffold decreases PST's oral argumentation performance. When course instructors assist PSTs, they should consider whether the uncertainty of the issue still invokes PSTs to engage in argumentation.

The study also has implications for researchers. First, previous research used ASAC mainly in ADI research, and ASAC was not used in SWH studies. This study showed that ASAC can also be used in SWH research to assess oral argumentation. Therefore, we advise future SWH studies to use ASAC to observe and assess participants' oral argumentation. Furthermore, the use of ASAC in SWH and ADI research can be a bridge for these two different ABI approaches. Second, some researchers might expect linear development of oral argumentation in SWH implementation, but this expectation was not met in this study. We think that context and task difficulty may impede the development of oral argumentation. For example; PSTs' oral argumentation performance decreased in some weeks in our study. Therefore, researchers should be careful when preparing the tasks. If tasks are very difficult, PSTs may not engage in oral argumentation although they become familiar with argumentation. Third, cognitive aspects of oral argumentation developed in this study and we attributed this development to participants' age and SWH implementation, but we do not know the exact factor. Researchers may conduct experimental research to understand the reason for cognitive aspects' development. Lastly, we think that due to PSTs' limited content knowledge and the short duration of the treatment, participants' oral argumentation's social aspects were limited. Future research can support primary school PSTs' fundamental science content knowledge before SWH implementation and SWH studies can last longer than this study. In this way, primary school PSTs might have better content knowledge and take advantage of longer SWH implementation. As a result, they can improve their oral argumentation more than this study's participants.

Limitations

The study has some limitations. First of all, the study focused on whole class discussions; therefore, this study does not inform about individual participants' oral argumentation performance. Future research may address individuals' oral argumentation process. Second, we did not use video recording in this study, so we might have missed some points or events during observations. However, two researchers observed the groups to catch all events and we discussed every detail after teaching to better understand the groups' performance. Third, the study can last longer and PST can benefit from SWH more, but still, we think that participants benefitted from SWH and they improved their oral argumentation.

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Ethics statement: In this study, we declare that the rules stated in the "Higher Education Institutions Scientific Research and Publication Ethics Directive" are complied with and that we do not take any of the actions based on "Actions Against Scientific Research and Publication Ethics". At the same time, we declare that there is no conflict of interest between the authors, which all authors contribute to the study, and that all the responsibility belongs to the article authors in case of all ethical violations.

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