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Contents Exploring the Preservice Science Teachers' Written Argumentation Skills: the Global Climate Change Issue

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The pedagogical methods and techniques used in teacher training programs are important tools to graduate qualified teachers. Argumentation, which is known as evidence based scientific discussions, is one of the most widely used tools in national and international literature. The aim of the present study is to explore the quality of Preservice Science Teachers (PSTs) scientific reports those were written by using online course documents regarding the climate change issue. The qualitative research method guided the present study. The effects of climate change on the Earth were explored in four sub-dimensions which are; glacier melting, drought, disasters and immigrations, endangered species. In order to examine the PST's nature of written argumentation, a rubric, developed by Kelly, Regev, and Prothero (2007), was used. The results of this study indicate that, PSTs' written argumentation tends to improve. The current study provides an initial picture of the argumentation writing practices of PSTs.

Keywords: preservice science teachers, written argumentation, climate change issue.

INTRODUCTION

In the past few decades, a significant amount of research has laid contributions of argumentation in science education (Aufschnaiter, Erduran, Osborne, & Simon, 2008; Clark et al., 2009; Duschl & Osborne, 2002; Jimenez-Aleixandrea, Rodrigez, & Duschl, 2000; Rivard & Straw, 2000; Sampson & Clark, 2008). These studies have consensus on the claim that argumentation increases students' understanding of science (e.g., Kelly, Chen, & Prothero, 2000; Kuhn & Udell, 2003; Newton, Driver, & Osborne, 1999), and makes thinking process visible by engaging student in scientific process (Allan, Seely, Holum, & Holum, 1991; Bell, 1997). Achieving scientific literacy is another benefit of argumentation applications (Brown, Reveles, & Kelly, 2004; Gott & Duggan, 2007). Roberts (2007) states that scientifically literate person

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can understand scientific context through reading and writing. "Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately" (National Science Education Standards, 1996, p. 22). Argumentation enables students to talk science, and written argumentation gives them a chance to write science (Kelly, & Takao, 2001). Taking argumentation as a core activity of science enables us to practice significant goals, such as analysis and interpretation of science classroom discussions and debates, especially for the purposes of understanding how students engage in the construction and evaluation of scientific knowledge claims (Duschl & Osborne, 2002).

The fruitfulness of argumentation as a tool for analyzing students' way of thinking, and understanding their reasoning mechanism has become popular in education (Kelly & Takao, 2001; Osborne, Erduran, & Simon, 2004). Many science education researchers (Duschl et al., 2002; Newton et al., 1999; Simon, Erduran, & Osborne, 2006) conducted studies for the use of argumentation in science pedagogy. Not only recent research but also many international and national level science education organizations such as the National Research Council (NRC) in the U.S. and the Turkish National Curriculum Developers in Turkey call attention to the importance of argumentation in science education. NRC (1996) identifies learning to make an argument as creating science. In Turkey, national education goals have been reorganized and these new goals have put forward argumentation into consideration new goals are taken to the Turkish National Curriculum agenda. According to these new goals, students are expected to make evidence based judgments in their everyday lives to construct scientifically accepted views and to make qualitative arguments (Ministry of National Education, 2005). Present study aims to give an example of PSTs' written argumentation skills as its being a popular issue in Turkey. Although it becomes popular in the national curriculum, the application of argumentation is not commonly used in classrooms. The reason that behinds this uncommon usage of argumentation in classrooms may be explained by the reason that teachers might be inexperienced on this issue. We began our project with preservice teachers since they form a good example for future science teacher.

LITERATURE REVIEW

Argumentation can be defined as, "[it] is a verbal, social, and rational activity aimed at convincing a reasonable critic of the acceptability of a standpoint by putting forward a constellation of propositions justifying or refuting the proposition expressed in the standpoint" (van Eemeren & Grootendorst, 2004, p. 1). As it can be seen from the definition of argumentation, it has not only verbal but also social and rational characteristics. While verbal and social processes of argumentation enhance students' communication skills, rational process of argumentation enhances cognitive process skills (Rescher, 1998).

Argumentation has a central role in the building of claims, explanations or models (Siegel, 1995). It has critical importance in science learning process and it should be supported in science classrooms (Zohar & Nemet, 2002). The current focus in science teaching is the role of spoken and written language (Jimenez-Aleixandre & Erduran, 2008). Students have chance to speak science in debates and argumentation, they also have chance to write science in argumentation writing activities.

Writing tasks became popular in science education, because of its immediate relation with thinking (Applebee & Langer, 1983). Written assignments help students to construct an understanding of science (Kelly et al., 1999), and to structure and organize knowledge in a consistent manner (Rivard et al., 2000). "How can I know what I think until I see what I say" famous query of Wallas (1926)

stresses the relationship between thinking and writing. Process of thinking or process of reasoning is hidden step of learning. Written argumentation texts expose this hidden step to view. Written arguments of students are worth to analyze because it develops higher order thinking skills, complex reasoning mechanism, and enhances reorganizing skills of students that help them to write in a coherent manner.

Prain and Hand (1999) asserted that writing tasks develop students higher order cognitive skills. Yore, Hand, and Prain (2002) strengthen this assertion by saying that students engage in so many tasks such as hypothesizing, reflecting and elaborating during writing activities. Because of these wide range contributions, written argumentation research has been given attention in science education over the past few decades (Duschl et al., 2002; Newton et al., 1999; Simon et al., 2006). Significant amount of researcher analyzed written argumentation skills of students (Kelly, Druker & Chen, 1998; Kelly & Takao, 2002; Keys, et al., 1999).

Preservice Science Teachers were engaged with argumentation by many science researchers in the literature (e.g., Erduran, Ardac, & Yakmacı-Güzel, 2006; Zembal-Saul 2009; Osana & Seymour, 2004). The importance of argumentation in knowledge generation and justification phase was highlighted in these studies. Erduran, Ardac and Yakmacı-Güzel (2006) presented a case study for the promotion of argumentation in Pre-service teacher education program. 17 PSTs were trained using a special pack, IDEAS (ideas, evidences, and argument in science education) pack. PSTs were expected to prepare a lesson plan which is designed as an argument lesson and were expected to implement in real classroom environment. The study focused on PST training program and highlights the importance of implementation of argumentation in science education program. They suggest teacher educators that learning to teach argumentation from novice to expert should be given importance. Zembal-Saul (2009) examined PSTs problems of argumentation practices, and presented a framework creating coherence for the design of teacher education experiences. The study results showed that suggested framework is a powerful tool for PSTs understanding and practicing skills for argumentation. Researchers criticize the inexperience of PSTs as scientific inquiry learners and inexperience about the nature of scientific knowledge. They highlighted the importance contemporary reforms in science education that emphasize content, practices and discourses of science since PSTs need to develop robust understanding of science and transform these understandings during their teaching life.

Osana and Seymour (2004) conducted a study to enhance PSTs argumentation and critical thinking skills about complex, educational problems. The researchers gave written text to PSTs and asked them to write critical argumentation reflection papers regarding the topic. PSTs conceptions and use of evidence was primarily focus of the researchers since evidence is an important component of reasoning and argumentation. Their second focus was about use of research evidence as an argumentation tool. PSTs have a tendency to use research findings during argumentation construction instead of an opinion or unsupported belief. Osana and Seymour's last focus was considering alternative perspectives. Alternative perspectives, other side of the opinion, are needed to take into consideration since they help the individuals to form strength argument. Current study has some similar goals with Osana and Seymour's study. We also give a chance to PST to engage in scientific research findings since the web site consists of articles regarding climate change issue. PSTs cited these articles in order to support their argument in their written argumentation reports.

THEORETICAL FRAMEWORK

Theoretical framework is based on Kelly et al. (2007)'s study that has been conducted with university oceanography students. The study aimed to explore oceanography students written argumentation skills regarding the plate tectonic and earth climate issues. The model for argumentation analysis has been framed as an application of Toulmin's (1958) layout of arguments. However, Toulmin's model is found typically insufficient to evaluate the complexity of dialogic reasoning (Erduran et al., 2004) the model was extended by Kelly et al. (2007). The present study is not attempting to clarify single move from data to claim so that adapted version of Toulmin argumentation model is found convenient. There are two reasons to use Kelly et al.'s (2007) rubric for the present study; first, it is easy to understand the evaluation criteria in the rubric, the questions that formulate the rubric are clear, understandable and easy to adapt our study. Second, we took into consideration the population characteristics while choosing the framework. Student population in the present study has similar characteristics with the study of Kelly et al. (2007). Both of the studies were interested in university students' reflection papers. There are five epistemic criteria in the rubric. Two of them (solvability, support) were regarding thesis statements, and three of them (convergence, sufficiency, and validity) were regarding lines of reasoning developed by the students.

Study focus and research questions

The present study focused on PSTs written argumentation skills. Argumentation writing ability is necessary for not only scientist but also students and teachers. So, new approaches about written forms of science, like argumentation, should be taught to students, teachers and also teacher candidates. Participants of the study have importance at this point because they are the next generation of teachers of science.

The study focuses on written arguments which are being practiced by scientists to construct and communicate knowledge claims (Gross, 1990; Myers; 1990; Yore, et al., 2002) and to support student learning in science (Kelly, et al., 2007; Keys, et al., 1999). This study enhances science education research related to argumentation writing in two ways. First, it is conducted in Turkey context. Although argumentation is not such a new theory, it became popular in science education over the last few decades. However, much of these research have been conducted in the United States and Western part of Europe; limited number of research has been conducted in Turkey.

Second, the role of the teacher is seen as one of the most important factor in education process. Well-qualified teachers are initial factor to implement argumentation in science education. It is stated that the way of teacher assembles a scientific argumentation task affects the students' products (Kelly & Chen, 1999). Argumentation requires moving away from the role of the teacher as the source of right answers (Simon et al., 2006) and shifting towards the role of the teacher as a facilitator (Zohar, 2007). Argumentation education for teachers is prerequisite for the application of argumentation in classrooms, since teachers' lack of pedagogical strategies to support students in engaging in argumentation (Zembal-Saul, Munford, Crawford, Friedrichsen, & Land, 2002). In order to implement argumentation processes proficiently in science classrooms, teachers have to gain experience in argumentation (Zohar, 2007). Taking into consideration the fact that teachers are valued as key factor in argumentation construction (Tabak, 2004), we did research on PSTs argumentation writing skills in the current study. This study is a more detailed analysis of how argumentation was facilitated by PSTs. The present study

examined Turkish preservice elementary science teachers' written argumentation skills and development of these skills with the increase in their argumentation experiences. The importance of teachers in these kinds of studies was stated by Driver et al. (1998). They found crucial, to improve teachers' knowledge, awareness, and competence in managing students' participation in argument and discussion. This is possible with organizing workshops for in-service teachers and increasing argumentation experience of preservice teachers during their undergraduate education. Both may contribute to future professional development of teachers.

The following research questions guided the investigation: What was the nature of PSTs' written argumentation regarding the global climate change issue? How did instruction driven by argumentation writing over a semester period influence PSTs' written argumentation?

METHODS

The present study is an in-depth description and analysis of a bounded system. Our system is bounded to 20 PSTs reflection papers regarding the effects of climate change issue on Earth. According to Creswell (2007, p.73), "case study research involves the study of an issue explored through one or more cases within a bounded system". Since there are four cases to illustrate the issue, it is a multiple (collective) case study which followed the guidelines provided by Stake (1995). In multiple case studies, the interest is in the issue to be investigated; not in the cases. These cases are chosen because understanding them will provide better understanding of the issue (Stake, 2005). Document analysis techniques were used to analyze the data. We analyzed the PSTs' reflection papers which were used as data source for present study. The qualitative research paradigm guided the study. PSTs' reflection papers for four cases were analyzed in detail; the semi-structured interviews with participants were conducted to clarify the reflection papers.

Context of the study

In this study, treatment was the instruction based on argumentation approach. Educational technology was used as an instructional tool for this goal. The instruction continued in the science method course, which is a must course in Elementary Science Teacher Education program in Turkey, and lasted in 14 weeks. This was the first time that students were introduced to argumentation teaching and learning practices. A lab manual, prepared by the researchers, was used as guideline. At the beginning of the implementation, this manual was distributed to PSTs. There was a definition of the argumentation, components of a strong argument, and examples of weak and strong explanations in the lab manual. The rubric was also included in lab manual. Evaluation criteria in the rubric were checked by the PSTs, and each criterion was discussed in the classroom before the implementation. PSTs had given satisfying information about assessment criteria. This led them to know what they should give importance in reflection papers. The components of scientific explanation (i.e. claim, evidence, and reasoning) were identified and the importance of using evidence to justify a claim was discussed with PSTs. In the first week, scientific process and certain characteristics of scientists were discussed briefly. The role of the instructor was as a guide to engage students with argumentation activities. The instructor assessed each paper weekly, wrote feedbacks on each report and discussed these feedbacks with every participant individually. As the course progressed (in each case) at the beginnings of the writing sessions, the researcher explained typical weakness of the previous reflection papers. At the end of each lab sessions, researcher interacted with the students and maintained a dialogue with them about their ideas and perceptions about the feedbacks. The

instructor did no more interaction with students while they were writing their reflection papers.

Students were asked to define basic principles of science and common characteristics of scientist. In the second week students argued following issues: How scientists select a problem? How they form hypothesis? How they support a claim? What is observation? How observation differs from interpretations? In the third week, basics of argumentation method were introduced to students. Relationships among data, claim, evidence, and warrant were exemplified.

At the end of first three weeks students were asked whether they want to participate in argumentation writing activity or not. Twenty students were volunteer PSTs for the present study. In the fourth week; volunteer students were instructed about writing a reflection paper. PSTs were given information about standard structure of a reflection paper. These sections are described as; summary, introduction, method, results, inferences, conclusions, and references. These sections were stated as specific requirements for the lab reports. In fourth week PSTs were also introduced the course web-site, created by the researchers. In the fifth week, a pilot study with a group of 5 PSTs was carried out to obtain initial results about the effectiveness and usability of the system and to assess the papers. Results of the pilot study showed that the web-site was understandable and usable for PSTs. For the remaining four weeks PSTs were engaged with the course web-site, and they were expected to write a reflection paper about the effects of climate change on the Earth each week. Every single student wrote four papers in total.

Researcher had students to complete all of the investigations for four lessons, assessed and provided feedback to students both individually and as a whole class. Feedbacks tended to focus on the different components of scientific explanation and how students could improve those components. These feedbacks, the researcher provided students on their explanations, also aligned with the goals of the science curriculum including critiques and suggestions about argumentation writing. For example, in glacier melting unit, one student reasoning was, "glaciers are melting because greenhouse gases are increasing" researcher critiqued his reasoning by writing,

> *You have to make explicit relation between greenhouse effect and glacier melting. You need to explain what greenhouse gases are and what the effects of these gases on the earth are. First you should proof that the greenhouse gases are increasing. You should give some graphical values or scientific explanations about the amount of greenhouse gases. Then you can clarify the relation between these two issues.*

The researcher wrote feedbacks on PSTs reflection papers each week. On the second and third week PSTs were given a handout indicating common weakness of their argumentation writings; still, individual responses are written on PSTs personal papers. The aim of this handout was twofold. First, we thought that if we announce students' specific mistakes without giving their name, remaining students can read and try to avoid doing same mistakes in their writings. Second, we want to encourage students about argumentation writing. We thought that personal feedbacks can discourage students; they can think that they are incapable of argumentation writing but if we announce these mistakes in public they can feel confident because typical mistakes are being done by other students.

Participants

The subjects for the present study included 20 senior undergraduate PSTs, 12 females and 8 males, from the department of elementary science education at a state university in Turkey. Of the 38 students in the classroom, 20 of them voluntarily participated in the current study. At the time this study was conducted all research participants were in their final year of teacher education and completed courses in

the major science disciplines such as general chemistry, analytic chemistry, organic chemistry, general physics, astronomy physics, and general biology. Environment and ecology courses had been covered as selective course. The participants had also completed several pedagogy courses that prepared them for teaching. PSTs had completed classroom management course, instructional method and strategies course, guidance course etc. As PSTs are going to be the science and technology teachers in the future they had also completed the Science–Technology–Society course. Although climate change issue is not a separate course, participants were familiar with this issue through environment and ecology courses. Environment and ecology course covers climate change issue as a detail chapter. Due to the fact that argumentation or written argumentation issues had not been addressed as a part of PST educational programs, this was the first time that PSTs were introduced argumentation issues.

The course web site

The researchers designed a course web site (www.argueglobalwarming.com) that provides raw data about effects of climate change on the earth. It is well known that climate change is an issue discussed very controversial, the researchers paid attention to present both side of the issue. The website included a variety of sources about global climate change issue. Students were asked to form arguable claims and to support them with sufficient evidences by using this web site. Effectiveness and validity of the included information have been checked by a geological engineering researcher who is a research assistant that has a special interest to climate change issue and global warming issue. Effects of climate change on the earth were accumulated under four dimensions which are melting polar ice, drought, natural disasters & migration, and effects of climate change on living organism. Each dimension consists of information links, media links, and country specific links. Furthermore, there are three extra links for figure and graphics, related photographs and related videos providing visual information about effects of climate change on the earth. The first author and geological engineer discussed every single information that is presented on web site. The PSTs were expected to analyze only one issue per week. The information on the web site does not direct them to any opinion. There were links, controversial news, photographs etc. PSTs were expected to use these data to form a claim and support it with sufficient evidence. Thus, we do not judge PSTs claims whether they are true or false. We focused on their reasoning mechanisms and use of evidence

Data collection

PSTs were engaged with the course website, and they were expected to write a reflection paper about the effects of climate change on the Earth. The purpose of the application was told to them at the outset of the term. In addition, they were explained that their papers would serve as their midterm score for the course. For each effect of climate change on the Earth, PSTs attended two hours of web-based sessions and two hours of writing sessions. While PSTs were asked to gather relevant data, graphics, and statistics during the web-based sessions, they were required to write a reflection paper during writing sessions. Each week they discussed related dimension of climate change issue and wrote reflection paper on that dimension in detail. Each student wrote four papers in total. These papers were used as a data source to examine PSTs' written argumentation. Each paper was collected weekly; feedback about the assignments was given to participants to improve their papers in the next assignment. Each week, the course assistant interviewed the participants to better understand and clarify their perspectives.

Data analysis

Merriam (1988) assert that data collection and data analysis must be a simultaneous process in qualitative research. The present study aimed to conduct these two steps simultaneously. PSTs written argumentation reports were analyzed each week. In order to examine PSTs' written argumentation, a rubric, developed by Kelly et al. (2007) was used in the present study. The rubric is presented in Appendix A. There are 17 questions in the rubric and each question was rated on a scale from 0 (non existent) to 4 (excellent). The rubric formulates arguments into two manners: structure of thesis (solvable and supportable or not) and structure of reasoning (convergent, sufficient and valid or not). The basis for the current analysis is described by Kelly et al. (2007) as follows:

Solvable and Supportable Thesis Statement: PSTs were expected to form a strong argument in order to make a good claim. They were also required to support that claim with evidence. If they find solvable thesis statement, they can form a strong argument and they can support their arguments.

Convergent Line of Reasoning: We state that thesis statement must be solvable in order to support it persuasively. Students can use multiple data to support a thesis. Every single data needs to support argument through different perspectives but when they came together they need to support the overall argument.

Sufficient Line of Reasoning: It is clear that, well-structured arguments include convergent line of reasoning. It is highlighted that, multiple line of reasoning is also important for well-developed arguments. Therefore, sufficient line of reasoning was analyzed in PSTs' reflection papers.

Valid Inferences: PSTs were required to support their thesis but this is not enough to write well developed reflection paper. They also should infer valid conclusion from available data if they want to form well developed paper. Hence, we looked for valid inferences in PSTs' reflection papers.

We assessed each paper weekly, wrote feedbacks on each report and discussed these feedbacks with every participant individually. As the course progressed (in each case) at the beginnings of the writing sessions, the researcher explained common deficiencies of papers and typical weakness of the previous weeks to the students. At the end of each lab sessions, researcher interacted with the students and maintained a dialogue with them about their ideas and perceptions about the feedbacks.

We used researcher triangulation to establish inter-rater reliability of the data analysis. The researchers selected five papers randomly and read each paper line-by-line, and graded papers by using 17 questions in the rubric. Each researcher reviewed the papers and assessed them independently. At the end of first reflection paper analysis two researchers came together and compare their grading. For example, first question was about thesis statement. If students have a research question and s/he describes his or her research question clearly, s/he takes maximum score for this question. There are 17 questions in the rubric, 14 of them was graded as the same score by two researchers, 3 of the questions (Question 9, 11 and 14) were graded differently, according to first researcher student used relevant data and explained them explicitly to support his explanation, however second researcher find data relevant but insufficient to support his explanations. Researcher discussed their stand points and made a decision, which kind of data (graphics, statistical results, videos etc.) will be accepted as sufficient data, what are the criteria to mark thesis statement as "clear" or "not clear"? How will "multiple lines of reasoning" identified? etc. Researchers continued the analysis with remaining four papers. For second paper (question 3 and 5) and third paper (question 11 and 17) there were still 2 differences between grades. Finally, on fifteen papers there were no differences between two researchers' grades. The rate

of agreement on the assignment results between two researchers was 90%. Because of the high consistency between researchers, remaining papers were assessed by the first researcher.

Member checking is basically defined as an opportunity for members or participants to check particular aspects of the interpretation of the data they provided (Merriam, 1998). Member checking can be an individual process or can take place with more than one person at a time, such as a discussion with the researcher (Doyle, 2007). We assessed each paper weekly, wrote feedbacks on each report and discussed these feedbacks with every participant individually. As the course progressed (in each case) at the beginnings of the writing sessions, the researcher explained the nature of the papers to the students and typical problems of the previous weeks. At the end of the each lab sessions, researcher interacted with the students and maintained a dialogue with them about their ideas and perceptions about the feedbacks.

In the pilot study, PSTs wrote their reflections by their handwritings. During the analysis of these papers, there were some papers which were difficult to read. Researchers need the participant's help in order to read some parts of the reflection papers. Therefore, PSTs were asked to write their papers by using a word processor. Word processor was found useful for two reasons; first it minimizes the researcher biases to the reflection papers, if PSTs would wrote papers by their handwritings, a researcher should recognize writers by their handwriting. This can affect the researcher's attitude even positively or negatively. Second, word processor solved the readability problem.

RESULTS

We present our results in three parts. In the first part, we addressed PSTs' written argumentation, and presented results in Figure 1. We analyzed responses of PSTs considering each question stated in Appendix-A. Seventeen questions in the table were considered to analyze PSTs' written argumentation, and the total score of each question was calculated. Moreover, in this part, the findings obtained from two specific examples of PSTs were presented to better understand PSTs' argumentation. In the second part, we labeled each PSTs' score as low, medium, or high, and examined the frequency of these categories for each report. These categories obtained from PSTs' scientific reports are represented in Figure 2. In the third part, we calculated average argumentation scores of all PSTs for each week and presented findings in Figure 3. With this figure, we aimed to present PSTs' development of argumentation with their argumentation experience.

PSTs' Written argumentation

Our analysis consisted of four main categories: solvable and supportable thesis statements; casual coherence and multiple lines of reasoning; evidence and justifications; valid inferences (Kelly et al., 2007). Responses to the first and second questions state the structure of the thesis statement. Questions 3 and 13 stress the casual coherence and lines of reasoning mechanisms of PSTs. Quantities and qualities of evidence and justifications are detected with questions 6, 7, and 8. Finally question 16 looks for the validity of the inferences. Therefore, total scores of these questions are worth analyzing in order to define PSTs' written argumentation since these questions are most distinctive ones among all questions. Figure 1 shows the average scores of all PSTs' for each item in the rubric.

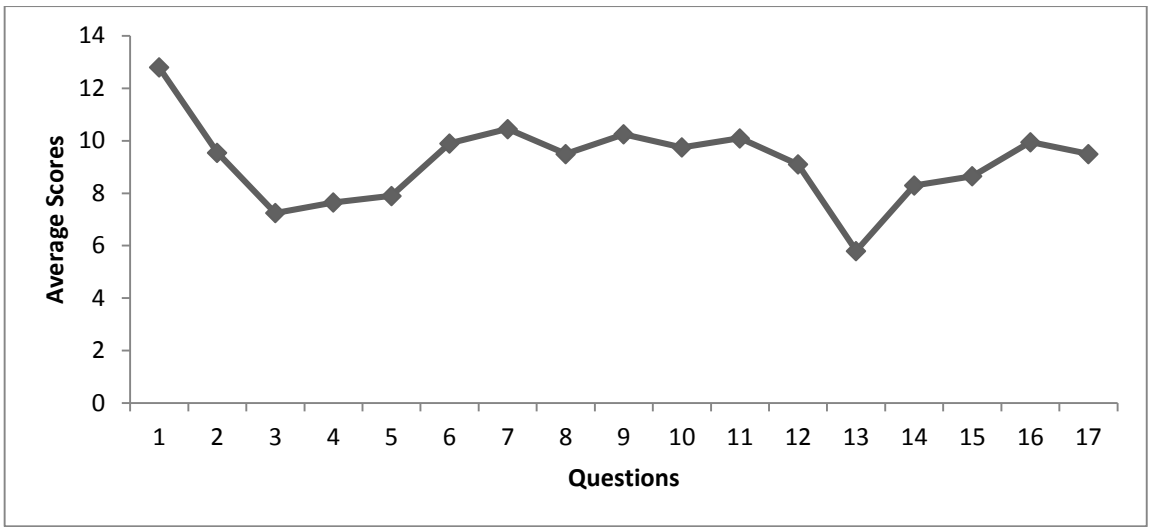

Figure 1. Average scores of all PST's for each item in the rubric

These average scores were obtained by dividing sum of scores for each question to 20 which is the number of students. For example; sum of scores for question 1 was 256 we divided 256 by 20 and get 12.8. In Figure 1, it is clearly seen that average scores of question 1 is between 12 and 14. For question 13, sum of scores was 116 which is divided by 20 and get 5.6 which also have been seen in Figure 1. The purpose of average score calculation for each item on the rubric is to see if there is common trend across questions. It can be clearly seen in Figure 1; the highest score belongs to question 1 and 2 which means that every student succeeds to pose solvable and supportable thesis statements. There is a sharp decrease in the average scores of question 3 and 13. Lowest scores belong to these questions which means that students have difficulty developing multiple lines of reasoning and describing a complex mechanism. General aptitudes across papers were well developed claims, well supported arguments, and well posed inferences. The most problematic issue was developing complex reasoning skills. PSTs have difficulty with this process.

In order to provide deeper understanding about PSTs' written argumentation skills, we focused on two PSTs' reflection papers. We purposefully selected these PSTs because they represented extreme or deviant cases. In extreme or deviant cases, outstanding success or notable failures, top of the class or dropouts, and crises are used as sample (Patton, 1987). In the present study, we exemplified the most successful and unsuccessful PSTs' scientific reports. Two extreme cases were chosen for a closer analysis in Appendix-A. Student Writer 1 (SW1) was categorized as writing weak arguments (coded LLLL); while Student Writer 2 (SW2) was categorized as writing strong arguments for all cases (coded HHHH). The overall scores for these two writers across the four papers are presented in Appendix-A.

SW1 offered similar arguments in four cases. In these cases, (i.e. glacier melting, drought, natural disasters & migration, effects of climate change on living organism) the student identified solvable thesis but lacked to pose evidentiary support for the thesis. For glacier melting paper the student stated a clear thesis statement as "*if glaciers continue to melt this will affect the sea level."* However, the student used only one graphic to support the thesis. He inferred that *if the glaciers melt, sea level rises.* This claim is essentially true but lacked the evidentiary support. Raw data includes statistical values regarding sea level, figure and graphics, NASA photographs etc. The students used none of them in his paper. The conclusion part of the SW1 reflection papers consists of an irrelevant claim as "*greenhouse gases causes glacier melting*" this claim is found irrelevant because the student had never mentioned the greenhouse gases across the whole paper but the end. He just concluded his paper with greenhouse gases. This was not the expected conclusion. All of the PSTs were

expected to form relevant claims, support these claims with sufficient evidence and make valid inferences and conclusions that are related with the full paper. The quality and quantity of the reflection papers showed no significant differences from glacier melting paper to living organism paper. There was irrelevant data, inferences and conclusions across the reflection papers. On the contrary, SW2 offered well-argued positions for four cases, and thesis statements were solvable and supportable. For example, SW2's thesis statement for glacier melting was clear and supportable she claimed that "*carbon dioxide is one of the dangerous greenhouse gases, if people cannot control the release of these gases to the atmosphere the greenhouse effect will increase, and the more greenhouse effect means the more glaciers melting*." She supported this claim by using figures and graphics. She used Figure 2 to explore her claim. She stated that glacier melts. She also used NASA arctic ice melt photographs to support the claim. She collected data about carbon dioxide level in the atmosphere for last 100 years. The student also develops complex reasoning mechanism. She did not move from single data to claim. She used multiple relevant data (e.g., articles, graphics, NASA statistics) to describe a mechanism, to support an explanation. The student's inferences were also relevant to the topic.

Both writers were engaged with the same issue at the same time. Glacier melting case is selected an example case to explain their writings. SW1 argued that "sea level rises due to the polar ice melting". This thesis was clearly stated but poorly supported in the paper. SW1's first reflection paper consists of a single page including summary, introduction, method, observation, inference and results parts. There was an outline for the issue but not detailed explanation for related parts. SW1 claimed that "if glaciers melt, sea level rises all over the world". There was neither a graphical value nor piece of evidence to support this thesis. In observation part, some statistical results were used to indicate increase in the earth temperature. However, there is still lack of evidence to make a connection between glacier melting and earth temperature. In conclusion part, student posed an irrelevant claim as "greenhouse gases cause global warming". This claim was stated as irrelevant because there was no explanation about greenhouse gases across the whole paper.

SW2 offered well organized paper for glacier melting as opposed to SW1. This student argued that "as greenhouse gases increases, global temperature will increase". This claim was evidenced by using figures and graphics. Figures and graphics were used to explain the relationship between greenhouse gases and polar ice melting. Some statistical data were used to justify this thesis statement. Increase in the amount of greenhouse gases was indicated in the reflection papers and some inferences were figured out. Data were used to describe a mechanism. Student developed multiple lines of reasoning, including the effect of greenhouse gases on glacier melting, contribution of developed countries to CO_2 emissions, and probable scenarios for the effects of glacier melting on the earth.

Categorization of PST's written argumentation

As previously mentioned, there were 17 items on the rubric. If a PST presents clear example for each item on the rubric s/he gets highest score which is 68 (17 times 4) if s/he fails to present clear example for items s/he gets lowest score which is 0 (17 times 0). In light of the data, PSTs' scores were placed into three categories. These categories were: low, 0 to 23 points (L), medium, 24 to 45 points (M), and high, 46 to 68 points (H). The frequencies of these categories were calculated for each paper and stated in Figure 2. Number of low categorized papers (12 papers) decreased from first report to the fourth report. Meanwhile, number of medium categorized papers (41 papers) showed an inconsistent trend. Some of the low

categorized papers in first reports showed improvement and categorized as medium in second report. But this increase ended in third and fourth reports, as seen in Figure 2, number of medium category decreased from second to fourth reports. Finally, the numbers of high categorized papers continuously increased. PSTs seem to show greatest improvement from first report to last report.

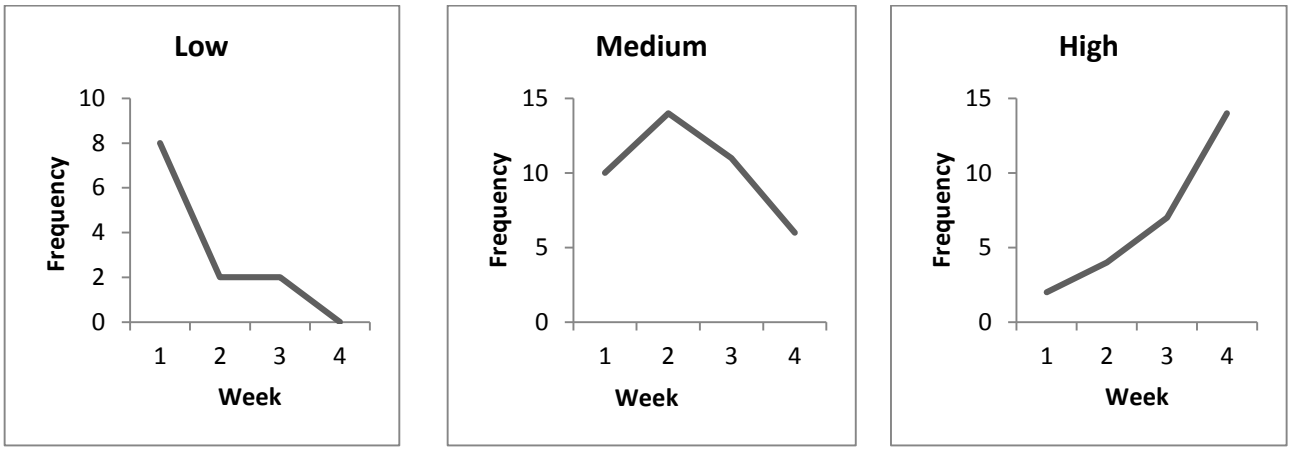

Figure 2. Frequencies of PSTs' written argumentation categories for each week

As observed in Figure 2, the frequency of students' low score categories decreased throughout the implementation period. As opposed to the low category, the frequency of high scores increased throughout the oncoming weeks. Overall, if we exclude the last week, the general trend across papers was medium-category. Last week is exceptional because there was only one low categorized paper and four medium categorized paper, remaining papers (13 papers) were categorized as high level.

PSTs' argumentation development with their argumentation experiences

We compared average scores of PSTs' reflection papers, considering four scientific reports. The averages scores of the four scientific reports are presented in Figure 3. The minimal average belongs to the first weeks' reports. We added all students' personal scores and calculated class average. In the first report, PSTs average score is 27. There is slight increase in the second week report score which is 36. Moreover, PSTs average scores have shown visible increase in the third and fourth reports as 42 and 50. We may claim that written argumentation of PSTs improved through the scientific writing experience during the implementation period.

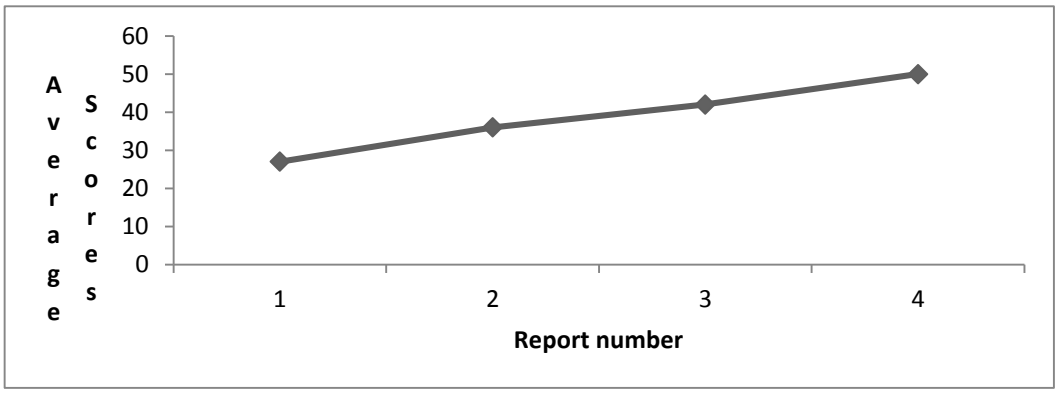

Figure 3. Average scores of all PSTs' for each scientific report

DISCUSSION AND IMPLICATIONS

The aim of the current study was to engage PSTs with argumentation writing activities and to analyze their argumentation in light of their reflection paper. Our discussion section was framed around two research questions. First, we investigate PSTs' written argumentation skills regarding the climate change issue. Second, we explored the improvements of PSTs' scientific reports' across the four cases.

The current study provides an initial picture of the argumentation writing practices of PSTs. This study can be seen as an analysis of PSTs' use of data as evidence in explanation of multiple effects of climate change issue on the Earth. According to results, we determined two different quality groups of papers in this study. First group of papers are stated as high quality argumentation papers while second group are stated as low quality argumentation papers. In this study we have argued that in order to formulate a high quality argumentation, PSTs have to state solvable research question, sufficient line of reasoning, and construct valid inferences from raw data. The present study showed that while PSTs in both groups posed solvable thesis, significant difference occurred in developing multiple lines of reasoning and describing complex mechanisms.

The first group PSTs supported their arguments with proper evidence, posed solvable and researchable thesis statements, and developed complex reasoning mechanisms about the given issue (i.e., glacier melting, drought, disasters & migration etc.). On the contrary, the second group posed solvable and researchable thesis statement but lacked multiple lines of reasoning skills. The common properties of these papers are their inadequate structures both qualitatively and quantitatively. For example, some of the PSTs' (student 8 and student 11) argumentation papers were limited with only one page. There were only the sub-headings of their reflection paper (abstract, introduction, method, conclusions, inferences), and some copy-paste information that was directly taken from the web site. They also lack the ability to describe complex mechanisms. The findings align with the work of Kelly et al. (2007) in terms of the quality of papers. In Kelly's work, university oceanography students were required to gather relevant data and write scientific position papers regarding plate tectonic and earth climate issue. Students, both in low and high category, offered a well posed thesis whereas first group have trouble in describing a complex mechanism. The reasons for difference in argumentation quality can be caused by different prior knowledge and different ability to understanding the information given on the website. There is numerous research that was conducted with PSTs to promote their argumentation in science education research literature (e.g., Erduran, Ardac, Yakmacı-Güzel, 2006; Ikpeze, 2007; Sadler, 2006; Roasen et al., 2010; Zembal-Saul et al., 2002; Windschitl, Thompson, & Braaten, 2008). These studies showed consistent results in that PSTs have difficulty to support their claim, to organize their ideas, and to develop complex reasoning mechanisms. The findings of the present study were also in line with the findings of the study of Zembal-Saul et al. (2002). They investigated four PSTs' argumentation texts regarding the evolution unit. Similar to present study, PSTs in Zembal-Saul's study had difficulties developing complex reasoning mechanisms and thinking alternative cause and effect relationships between cases.

Sandoval (2003) examined high school students' argumentation skills regarding natural selection unit. The common findings of this study alerts that students have difficulty to support their claims with appropriate evidences. Students' inadequate use of evidence was also criticized. In light of these findings, it is obvious that not only university students but also high school students have similar problems in argumentation writing. Students were required to argue different cases in a coherent manner which is only possible with well-known topics. Students may not

have knowledge about how to support claims with appropriate evidence and reasoning. Students lack of experience can be possible explanations for their deficiency in argumentation writing. Experience may help developing complex reasoning mechanisms and thinking alternative cause and effect relationships between cases. Argumentation activities should be included in the science curricula because its positive effects on developing complex reasoning skills. Still, further research will need to examine why students struggle to produce arguments with multiple lines of reasoning during argumentation writing process. Answers to this question will enable science education researchers to develop instructional practices to promote and support more productive argumentation writing engagements in science classrooms.

Zohar (2008) suggests that teachers must gain experience in high quality argumentation themselves in order to support students' successful argumentation. Teacher professional development programs aims to elicit teachers' evidence-based implementations (Gerard, Spitulnik, & Linn, 2010). We engaged PSTs with argumentation writing activities because of the importance of teachers' in argumentation process and the significance of argumentation experience in the literature. The results of this study indicated that PSTs' written argumentation tends to improve with argumentation experience. These findings align with the work of Simon, Erduran and Osborne (2006). Simon et al. (2006) studied with practicing teachers and reached similar conclusion with the present study. They concluded that argumentation teaching skills can improve with experience. In present study, PSTs were also given opportunities to engage in argumentation activities which are conceptually rich and intellectually demanding activities. Our findings suggest that argumentation skills can develop with argumentation experience. Moreover, argumentation activities enhance complex reasoning skills. In order to enhance these skills argumentation practices should be increased in science classes. It is obvious that in order to teach argumentation efficiently, teachers should have sound experience of argumentation. Therefore, efforts to promote argumentation in science classes should be enhanced with both practicing teachers and Pre-service teachers.

Argumentation writing experiences may model reasoning processes that can be emulated in science education. These types of experiences and activities can contribute to teacher education. In numerous science education programs around the world, there is an increasing emphasis on the inclusion of argumentation in science education. However, there is still significant gap between the theoretical objectives and practical applications of argumentation in science curricula. Future research is required to extend application scenarios of argumentation in science and to translate their findings in teacher training programs as well as in service teacher education programs.

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