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Applying Online Learning Environment for Argumentation of Students with Different Level of Prior-knowledge

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Abstract: Science argumentation is an essential element for improving students' science literacy. This study adopted a quasi-experimental design to investigate 121 eighth-grade students' learning of science argumentation. An online learning platform was developed to collect and interpret data of their argumentation online. Two independent variables: students' prior knowledge (low, middle and high) and form of argumentation approach (personal and social) were concerned in this study. The dependent variables included: science knowledge, science argumentation, and the outcome of argumentation in the e-learning platform. The results showed that both the two independent variables have significant effect on the students' argumentation. Prior knowledge is a base supports the construction of sound argument. Learning with social approach provided opportunities for students to share their understanding of science concept and co-construct arguments through knowledge reflections. For the suggestions of the teaching for argumentation, to provide explicit, sequencing, and clear scaffoldings would be important both for the students' learning of science concept, and their development of argumentation ability.

Keywords: Online science learning environment, Science argumentation teaching, Students' prior knowledge

1. Introduction

Scientific literacy is an important goal of science education. As two essential abilities for achieving science literacy, science inquiry and argumentation have become significant issues in recent years. Based on previous studies, it is reported that argument has a personal and social meaning. (Jiménez-Aleixandre and Erduran, 2008; Kuhn, 1993). The personal meaning refers to a person's individual and internal discourse. However, the social argumentation refers to a discussion and/or a debate between people with different/ opposing of views to an issue (Jiménez-Aleixandre & Erduran, 2008). The indication above explains that there are at least two forms of argumentation can be divided in the teaching of argumentation, namely personal and social argumentation. First, for the personal argumentation, it is explained that the personal argumentation involves self-reflection and inner reasoning thinking process in order to produce an argument. However, the second one means that argument can be generated form a group with differences in opinions between people. This study attempts to explore the influences of the two kinds of argumentation on students' science learning, including students' science knowledge construction and argumentation abilities. Except the form of argumentation approach, students' prior knowledge is also an important factor for the comprehension of science knowledge (Cook, Carter, & Wiebe, 2008). Zohar and Dori (2003) explain that students with high-level prior knowledge may outperform than their peers with low-level prior knowledge in various kinds of abilities and skills due to that the low prior knowledge students tend to pay more attention to the surface features of learning materials. Nonetheless, when appropriate instruction is provided, low-achieving students can perform as well as their peers of high-achieving students (Ben-David & Zohar, 2009; Grimberg & Hand, 2009). We were curious whether the student prior knowledge effect their argumentation for both personal and social argumentation approach. The present study investigated such kind of affections through an online environment we developed

for increasing the students' scientific argumentation abilities and their learning of related scientific concepts. We proposed two research questions as follow:
(1) Does the students' prior science knowledge and form of argumentation approach online on (personal and social) influence their learning of scientific concepts?
(2) Does the students' prior science knowledge and form of argumentation approach online on (personal and social) influence their learning of scientific argumentation?

2. Literature Review

2.1 Science learning through the Internet

In science education, online learning is often used to improve students' ability to understand and explore complex scientific concepts (Rutten, Joolingen, & Veen, 2012). One of the reasons why the online environment helps students to learn scientifically is to help students construct accurate scientific concepts (Trundle & Bell, 2010) in an image. In addition, scaffolds can be embedded to train students' high-level scientific ability (Weng & Lin, 2017). However, how to use scaffolding to effectively promote the process of producing high-quality arguments is not an easy task for designers. The common problem of scientific argumentation learning is that students are not easy to propose diverse arguments, do not understand scientific evidence, and lack rational attitudes (Koschmann, 2003).

Nielsen (2013) said that people involved in social arguments are always have more opportunities to understand and discuss each other's ideas to gain diversity of thinking, importantly, they tended to rebut and question others' ideas. However, relevant research indicates that the practice of cooperative arguments rarely occurs in the general classroom, because the traditional classrooms follow the teacher's single teaching model: questions, answers, and evaluation, such model doesn't support students' cooperation, but also easy misunderstanding of science which is only the study of knowledge and memory (Kilinc & Demiral &Kartal, 2017). Many scholars develop a scientific online social learning environment to improve students' scientific understanding and argumentation (Sampson & Clark, 2007; Weinberger et al., 2010). Clark and Sampson (2007) developed program in which the students were allowed to describe the data they collect, present claims, explore evidence, and collaborate with each other in online activities. This learning process gives students the opportunity to form a preliminary theory and refine it through discussion. Weinberger et al. (2000) explored online scripting into scientific argumentation learning. They carefully designed online social learning situations and applied templates and scripts to suppport students' construction of high-quality arguments (Weinberger et al., 2010). Such scaffolding design concepts have also been applied in the present research to promote students' high-quality scientific argumentation capabilities.

2.2 Prior-knowledge and Students' Scientific Study

There are various assertions regarding the relationships between the students' science learning and their prior-knowledge (ie, high, middle and low prior-knowledge students). A number of scholars believe that low prior-knowledge students have greater potential; another group of scholars do not think so because they basically need more teaching support. For example, Grimberg and Hand (2009) point out that although high and low prior-knowledge students have similar range of cognitive operations, students with high achievers can enter the advanced cognitive operation faster than those with low achievers. Such a feature explains the main reason why high-achieving students outperform low-achieving students in a number of scientific thinking skills.

For most of the traditional science classrooms, prior knowledge is always overemphasized because both teaching and evaluation are based on concepts and memory (Weinberger, Stegmann & Fischer, 2010). Some teachers believe that high-achieving students will perform better than low-achieving students. In order to challenge such traditional concept, Zohar and Dori (2003) compare the scientific thinking abilities (e.g., raising scientific questions, scientific arguments, and scientific critical thinking) of high and low achievement students in several different biological topics. They indicated that although high-achieving students scored higher on most scientific abilities than low-achieving students, low-achieving students showed better progress in one of the study cases.

3. Method

3.1 Participants and Procedures

Our quasi-experiment was carried out in 4 eighth-grade classes. There were totally 121 students arranged to participate in the present study. In terms of the variable of the prior knowledge, this study divides the student's knowledge level according to the science total score of the previous semester, which is divided into high (N= 41, mean = 84.4), middle (N= 40, mean = 76.7), low (N = 40, mean = 66.9) three groups. In terms of online argumentation approach variable, they are divided into personal argumentation groups (N= 62, mean = 74.7) and social argumentation groups (N= 59, mean = 76.1); there is no difference in grouping between them. (p = .158). Based on these two variables, we use the 2×3 quasi-experimental design principle. Classes are randomly grouped, and each social demonstration team in the social group consists of three to four members.

Before attending the online learning program, all students conduct scientific concept tests [SCT] and scientific argumentation test [SAT] before and after the subject of the experiment. The independent sample t-test of the pretest showed that the difference between the two groups of students (the social argument and the personal argument) doesn't reached significant difference (scientific concept test, p = .421; scientific argument test, p = .782), indicating that the two groups were selected Randomly assigned research hypotheses.

3.2 Development of the Online Learning Environment

The OSAE [online science argumentation environment] was developed based on the four topics (combustion, heat preservation, chemical reaction, and conservation) from the current science content of junior high school. The first part of the online learning platform provides students with relevant contexts for the subject of the science unit. The second part contains a series of well-designed multi-media textbooks, through which students conduct scientific arguments. For example, in the conservation unit, we first ask questions that focus on scientific knowledge. Students must understand the concepts related to the conservation topic and provide answers. Then, we design an argumentation question and ask them to response based on the main scientific concepts of the unit. In order to promote students with high-quality arguments, online learning environment provides students the definition of four arguments (claim, basis, support, and rebuttal); in addition, a template-type scaffolding is provided to allow students to learn and apply scientific arguments (Figure 1).

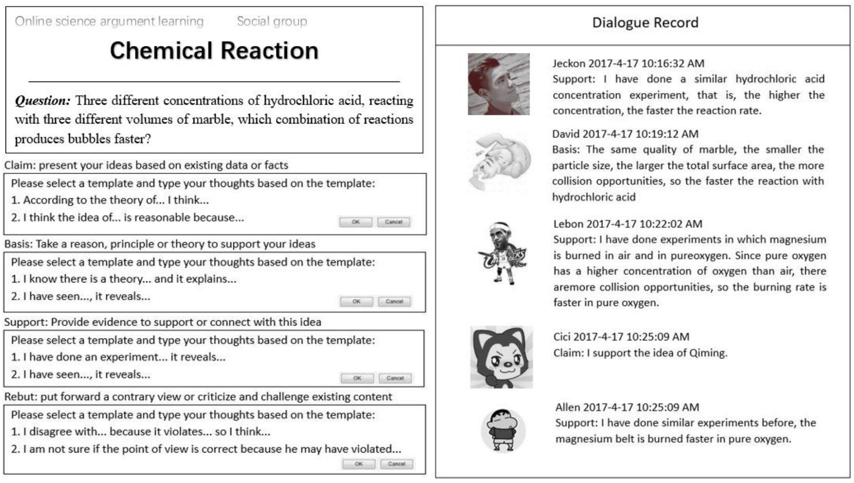

Figure 1. An interface of the OSAE for students' collaborative argumentation

3.3 Tools

There are two tests included in the present study: SCT and SAT. The SCT is a diagnostic test with multi-choice which are used to measure students' understanding of scientific concepts. The validity of the content was constructed by two master degree science teachers, which ensured that the questions in the test were related to the four selected chemical topics. In terms of content, each chemistry topic consists of five questions. Each question has two levels. Students must correctly answer the two levels of each question to get a score. The test reliability is 0.81.

The SAT is used to examine the students' ability to demonstrate scientific evidence. As with the scientific concept test, each argument (claim, basis, support, or rebuttal) generated by all students is divided into two different levels. The parameters of level 2 and level 1 give points of 2 and 1, respectively. The construction of the rating standard is based on the standards of Osborne, Erduran and Simon (2004). For example, if a student makes a claim (e.g., the quality of the chemical reaction is constant), but there is no data (e.g., experimental data), or a reason (e.g., because of the law of conservation of mass), then it will be judged as a level one claim, got one point. Students in the online learning environment, the evaluation of the proposed arguments, also scored in the same way. The reliability of the SAT is fine (0.92).

3.4 Data Analysis

We applied two-way ANCOVA to analyze the influence of the two factors (online learning approaches and the level of prior science knowledge) on the students' performances on SAT and SCT. An argument quality framework was developed by Erduran, Simon, and Osborne (2004) is applied and for constructing our coding framework to analyze subjects' argumentation and their statements on the internet for both the personal group and the social group. Through the coding framework, we can classify every statement into two grades of arguments for the four components of argumentation concerned in the present study (claim, basis, support, and rebuttal) First, for a claim with supporting facts, reasons, and data was seen as a high-quality claim (Level one); a claim without any supporting facts, reasons, and data was treated as a low-quality claim (Level two). A support with (without) some connection to claim and basis was considered as a high quality (low quality) support. A basis with (without) some supporting theory was interpreted as a high quality (low quality) basis. A clear or identifiable counterclaim was interpreted as a high-quality rebuttal, otherwise a blurry or weak counterclaim was treated as a low-quality rebuttal. High and low-quality arguments were given two and one points, severally. Inter-rater reliability was fine (0.84). Based on the results of statistical analysis, we adopt the strategy of content analysis to explore the learning differences of two groups of students (personal and social), as well as students with different prior-knowledge.

4. Results

4.1 The results and improvements regarding the SCT

Table 1 shows the results of covariance analysis of the SCT. The data indicates that the average score of the social argumentation group is slightly lower than that of the personal argumentation group. For example, the average score of the post-test group is 19.54, and the score of the personal argument is 20.29. For the comparison results of the pretest and posttest, the T-test of the dependent samples showed significant differences between the two groups (social argument group: $t_{(58)}=6.44$, $p<.001$; personal argument group: $t_{(61)}=7.376$, $p<.001$). This result continues to show that the scientific concepts of both groups have made significant progress. The SCT scores for the three prior-knowledge group students (high, middle, and low level groups) were 12.50, 17.18, and 18.61 respectively. However, in the posttest, the scores rose to 16.38, 20.48, and 22.85. The dependent sample T test showed that the three groups of pretest and posttest also achieved significant progress (high group: $t_{(40)}=5.04$, $p<.001$; middle group: $t_{(39)}=4.54$, $p<.001$; low group: $t_{(39)} = 4.96$, $p < .001$).

In terms of two-way ANCOVA and follow-up Sidak test, we found that the factor of argumentation approach had no significant effect on the student's performance of SCT ($F_{(1)}$ = .701, p = .756), while the other factor, students’ prior knowledge was found significantly effect on the students’ score of SCT ($F_{(2)}$= 13.741, p <.001). The post-mortem analysis further pointed out that the students with high prior-knowledge scored significantly higher in the examination than the students with the first-level knowledge, the average difference was 5.71 and reached significant (p <.001); the students with the first-level knowledge scored in the exam. Students with significantly higher than low prior-knowledge had an average difference of 3.78 and reached significant (p < .001). This result shows that in the scientific concept test, the impact of the prior knowledge is more than the social and the personal learning approach.

Table 1

The results of the two-way ANCOVA analysis of the SCT

	Mean (SD)				
Source	Pretest	Posttest	df	F	Post-hoc test
Approach			1	.701	
Social group(N=59)	15.56(5.03)	19.54(4.64)			
Personal group(N=62)	16.65(5.15)	20.29(4.93)			
Level of prior science knowledge			2	13.741***	(M) > (L)***
Low-level group(N=40)	12.50(4.42)	16.38(4.92)			(H) > (L)**
Middle-level group(N=40)	17.18(3.87)	20.48(2.90)			
High-level group(N=41)	18.61(4.88)	22.85(3.90)			
Approach × Level			2	2.956	

Note: (L), low prior-knowledge group; (M), middle prior-knowledge group; and (H), high prior knowledge group.
* p < .05, ** p < .01, *** p < .001

4.2 The results and improvements regarding the SAT

Table 2 presents a summary of the descriptive data and two-factor covariance analysis of the scientific argumentation test. The T-test of the social argumentation group and the personal argumentation group showed significant differences (social argumentation group: $t_{(58)}$=7.37, p<.001; personal argumentation group: $t_{(61)}$=7.99, p<.001), indicating two significant progress was made before and after the group. In addition, the high, middle, and low prior-knowledge students' sample T-tests showed that they all achieved significant progress in the three groups (high group: $t_{(40)}$=4.53, p<.001; middle group: $t_{(39)}$= 6.79, p<.001; low grouping: $t_{(39)}$=7.49, p<.001).

In terms of two-way covariance analysis, we found that the learning pathway has a significant impact on the student's scientific concept test ($F_{(1)}$= 7.61, p <.01), and the Sidak test showed that the social argumentation group had significant better performance on the SAT than the personal argumentation group. On the other hand, the factors of students’ prior knowledge didn’t reach the level of significant effect.

Table 2

The results of the two-way ANCOVA analysis for the SAT

	Mean (SD)				
Source	Pretest	Posttest	df	F	Post-hoc test
Approach			1	7.61**	(S) > (P) **
Social group(N=59)	28.10	39.37			
Personal group(N=62)	26.23	35.24			

Level of prior science knowledge			2	2.33
Low-level group(N=40)	20.75	33.30		
Middle-level group(N=40)	27.12	37.95		
High-level group(N=41)	33.39	40.44		
Approach × Level			2	2.63

Note: (S), Social group; (I), Personal group.
* p < .05, ** p < .01, *** p < .001.

4.3 The results and improvements regarding the OSAE

The results of the two-way repeated measure ANOVA of the OSAE were showed in the table 3, we found that the main effects of the learning pathway ($F_{(1)}$=13.67, p<.001) and the prior knowledge ($F_{(2)}$=33.73, p<.001) have achieved significant results. The learning pathway Sidak test indicates that the students in the social group performed significantly better than the students in the group alone. The Sidak test indicates that students with high prior-knowledge perform better than those with middle and low prior-knowledge; those with middle prior-knowledge have lower performances. As the topic progresses, the performance of the students on each topic is better and better than the previous ones ($F_{(3)}$=48.85, p<.001).

Table 3

The results of the two-way repeated measure ANOVA for the OSEA

Source	SS	df	F
Subject	2435.85	3	48.85***
Approach	642.03	1	13.67***
Level of prior science knowledge	3167.81	2	33.73***
Approach × Level	40.42	2	.43

Note: (S), social group; (I), personal group; (L), low prior-knowledge group; (M), middle prior-knowledge group; and (H), high prior-knowledge group.
∗p < .05, ∗∗p < .01, ∗∗∗p < .001.

The performance of the online scientific argumentation of the four personal units of the personal argumentation group and the social argumentation group is shown in Figure 2. The ANOVA indicated that the argumentation approach had a significant effect on the first three modules (unit 1, $F_{(1)}$ = 8.76, p < .001; unit 2, $F_{(1)}$ = 9.59, p <.001; unit 3, $F_{(1)}$ = 9.45, p<.01). However, in the fourth unit, the difference between the two is not significant ($F_{(1)}$ = .212). The Sidak test further pointed out that the arguments of the social group students were better than those of the personal group. The scores of the two groups of students in the four units gradually increased.

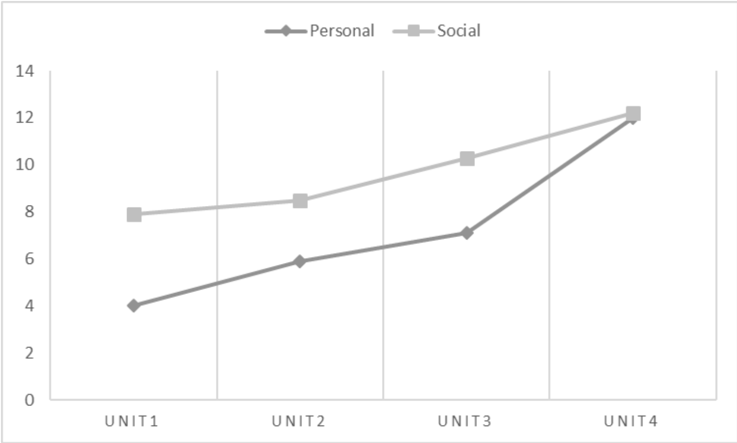

Figure 2. The distribution of average scores of students' scientific argumentation online for the four topics

The statistical results of the three sets of students with advanced knowledge level in online scientific argumentation are shown in Figure 3. One-way analysis of variance analysis showed that the main effects of the prior knowledge were significant on all four units (unit 1, $F_{(1)}$=12.74, p<.001; unit 2, $F_{(1)}$=16.66, p< .001; unit 3, $F_{(1)}$=18.86, p<.001; unit 4, $F_{(1)}$=15.80, p<.001). The Sidak test analysis further pointed out that students with high-priority knowledge in the four units scored significantly higher than those with middle and low-priority knowledge. All students scored gradually in four units.

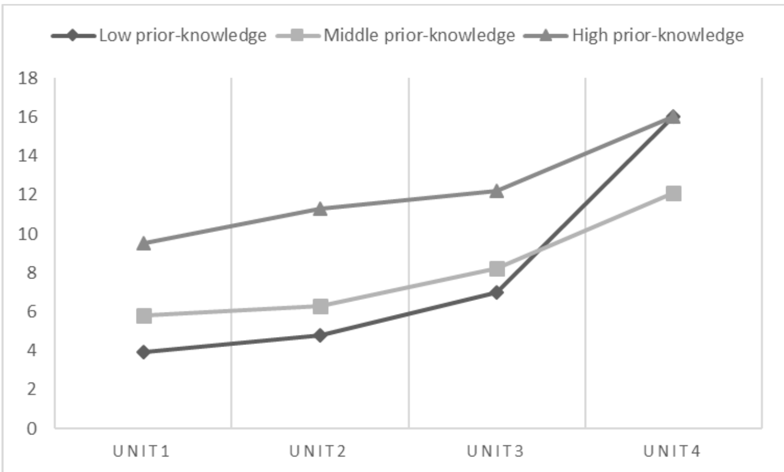

Figure 3. The distribution of average scores of students' scientific argumentation online for the four chemical topics

5. Discussion and Conclusion

The results of the present study show that both argumentation approach (social or personal) and student prior knowledge had significantly impact on the students' learning of argumentation. For the factor of learning approach, the social group students outperformed than their peers in the personal group for both SAT and OSAE scores. Our outcomes are build-up with the studies with emphasizing on students' collaborative argumentation which indicating their communication/critique skills are closed related to their argumentation ability (Clark & Sampson, 2008). In other words, dialogue interaction in collaboration is very important for students' knowledge co-construction and peers' evaluation of their arguments, including claim, basis, support, and rebuttal (Berland & Hammer, 2012). In students' argumentation of personal version, they tend to construct arguments by using reflection that is, they may reflect what they had learned to construct their claim or rebuttal and such kind of thinking process is actually a reflection of their prior science knowledge (Hmelo, Nagarajan,

& Day, 2000). This reason supports that student's prior science knowledge is related to the students' production of the arguments. For the factor of prior knowledge, the OSAE program is designed as anonymous, the students were allowed to use a pet name for making response and provide statements. This design would enable them, expecially for the low or middle prior-knowledge students to make statement freely, in other word, they may have lesser peer pressure under the anonymous discussion online system (Russell & Aydeniz, 2013). These reasons explain why low prior-knowledge students acquired significant improvements regarding their arguments especially from topic 3 to 4 in the OSAE. Argumentation in science classroom have both peers' idea-sharing and self-reflection parties, both part of the thinking or learning processes are essential for the argument construction, an inner thinking and knowledge reflection process (Crawford, 2000; Mcneill, 2009). Thus, it is matter for a science teacher to emphasize such argumentation thinking in their science teaching, they should provide more opportunity for students to argue collaboratively. It may involve to encourage students to practice how to propose questions, warrants, and reasons to back their assertion, importantly, to share their thinking, reasons, and ideas about the talking issue and moreover, to explain their knowledge recall, reflection, reevaluation processes about our and others' responses (Herrenkohl, Palincsar, DeWater & Kawasaki, 1999). Another suggestion for teaching argumentation would be that the templates and scripts in the online learning environment, the OSAE, the templates play important role for the students to generate quality arguments and to know that there are various arguments can be used for making response instead of just accept others' asseration. We believe such templates and scaffolds support students' collaborative argumentation, and peers' interactions which would be an important reason to explain their improvements in the present study.

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