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Infusing Explicit Argumentation in Science Reading Activities: Helping Prospective Science Teachers Reduce Misconception and Foster Argumentation Skills

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Abstract

Science reading activities play an important role in shaping and constructing new knowledge. The enactment of these activities was commonly used to develop scientific literacy and enhance students' understanding. However, lack of the study focuses on reducing misconceptions and developing argumentation skills. This study, therefore, aimed to investigate the effect of reading activities infusing argumentation activities in reducing misconceptions and advancing argumentation skills. We employed a quasi-experimental (non-equivalent control group design) by involving 72 prospective science teacher students as participants divided into experimental and control groups in the same proportion. The participants in the experimental group were involved to do science reading activities infusing argumentation activities whilst the control group was engaged in only science reading activities. All the groups did these activities for four meetings of which each meeting took 90 minutes. To elicit data, we used a three-tier test to measure students' misconceptions and a student survey to measure argumentation skills; both of which were tested before and after the learning process. The findings of the research showed argumentation activities infused in science reading activities have succeeded to reduce significantly students' misconceptions and develop argumentation skills. In addition, argumentation activities in science reading activities also succeed to drive students to propose comprehensive arguments and to improve the scientific quality of students' arguments. We ultimately discussed the implications arising from this study.

Keywords: Argumentation skills, misconceptions, science reading activities, anticipation guides.

Introduction

Science reading activities have pivotal roles in shaping and constructing students' knowledge (Vosniadou & Skopeliti, 2017). Actively students can construct several knowledge representations when they are reading science texts. For instance, science reading activities could facilitate reading comprehension skills (Lammers, 2019; Yang, 2016; Kloser, 2016; Cano, 2014). In this context, reading activities help students find key notions in several specific contents of science and they learn to create meaning-making from what they read. In a different context, science reading activities could train scientific literacy (Fang, 2008; Ford, 2006; Kachan, 2006; Wright, 2016). Here, science reading activities can be an effective way to drive the acquisition of important skills in science activities such as questioning, inferring, and predicting (Menesses et al., 2018). All these empirical studies have depicted that science reading activities have a crucial position like common activities in science teaching and learning such as laboratory activities.

Although science reading activity has several benefits in science teaching and learning, the use of scientific texts in this activity sometimes emerges problems. For example, the characteristic of scientific texts used is frequently difficult so students failed in constructing their knowledge (Snow, 2010). This situation could drive common phenomena that occur in science education in which students created misconceptions after reading scientific texts (Vosniadou, 2017; Goldman & Bisanz, 2002). In the other words, students failed to construct their knowledge when they failed in understanding the texts (Kendeou & Van Den Broek, 2005). In a different context, we considered that the use of science reading activity still lacks to be used to foster argumentation skills. In fact, an argumentation activity can facilitate someone to have critical thinking skills (Kuhn & Udell, 2007; Giri & Paily, 2020) to avoid misconceptions and to drive conceptual changes (Ogan-Bekiroglu & Eskin, 2012; Cetin, 2014). In this context, the emergence of science reading strategies can help how students construct their knowledge through reading activities.

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In order to complement empirical study related to science reading activities, this present study aimed to investigate how roles of the argumentation activities in science reading strategies affect the reduction students' misconceptions and improvement of students' argumentation skills. We here modify a reading strategy called Anticipation Guides (AG) by infusing explicit argumentation activities in it. By using this reading strategy, we facilitated students to construct scientific concepts of static electricity and to provide an opportunity to students to develop their skills in proposing scientific argumentation. Specifically, this present study examined to what extent science reading strategies infusing explicit argumentation activities affect the effectiveness in reducing misconceptions and fostering scientific argumentations. The following research questions were investigated in this study:

1. Do science reading strategies infusing explicit argumentation activities can reduce students' misconceptions of static electricity?
2. How is the effectiveness of science reading strategies infusing explicit argumentation activities in developing scientific argumentative skills?

Theoretical Frameworks

The role of reading on science learning

Reading activities play a crucial role in supporting students' achievement of learning objectives in science learning because they involve various complex thinking activities. In addition, reading activities also involve several kinds of complex cognitive processes (Michalsky, 2013), including scientific processes frequently facilitated through experimental activities in the laboratory, such as observing, classifying, inferencing, predicting, hypothesizing formulation, and elaborating questions. Thus, through reading activities, various kinds of practical thinking skills in science can be trained. In a different context, reading activities are essential for students to understand a scientific phenomenon (Rojas, 2019). In this context, scientific phenomena depicted in a scientific text can increase students' interest in learning after reading. This sense of interest becomes the essential capital to raise the enthusiasm and motivation of students in learning so that learning objectives can be easily achieved. Several other research findings found that reading activities carried out in the science learning process supported the achievement of acquisition of scientific concepts (Cano, 2014; Romance, 2017; Rojas, 2019; Probosari, 2018; Canaran & Mirici, 2020). All these empirical studies proved that knowledge construction could be built precisely and scientifically through reading activities.

Science reading activities

Reading activities in science learning are carried out in reading process stages: pre-reading, during reading, and after-reading (Rojas, 2019). The pre-reading stage is conducted to activate the students' previous knowledge. The during-reading stage is carried out to construct the new knowledge gained from the text and relate it with their experience. The after-reading stage aims to organize the obtained knowledge to become meaningful for students.

All stages in the reading process can be applied using a reading strategy in science learning classes. We here used the Anticipation Guides (AG), a strategy used to facilitate readers in understanding a text that can activate previous knowledge and relate it to a new knowledge written in the text (Pegg & Adams, 2012; Fenty, 2019). Herber (1978) developed AG with a scheme of activating students' prior knowledge before reading and then asking them to identify a series of statements while reading, whether or not they agree with these statements. The use of AG essentially asks students to predict what they think, read what the texts say, and explain the disparity between prediction and evidence (Patterson et al, 2018). This refers to components of AG encompassing several elements: statements of the content, what I think, what the texts say, and evidence of the text (Osborne, 2019).

In the context of the study, we modified AG by infusing explicit argumentation activities in it. The AG has four components as presented in the previous paragraph and we just modified the statements of the content and evidence of the texts. The statement of the content originally consists of several key concepts, the difficult concepts to be understood, and the concepts frequently causing misconceptions; we here added the problem statement taken from the texts and students should respond to them. In the evidence of the texts, we modified by writing components of written arguments separately: claim, data, warrant, and backing. All these components should be responded to by using information or knowledge from texts. We here provided an opportunity to students to create written arguments by classifying or separating information into components of written arguments.

Argumentation Skills and Misconceptions

The study of scientific argumentation has attracted many researchers in science education. Both argumentation activities and argumentation skills have become an essential component and a standard that must exist in science teaching and learning (National Research Council, 2012). In addition, scientific argumentation is accepted as a scientific practice that involves students constructing knowledge and thinking critically (Duschl and Osborne, 2002; Duschl, 2008; Erduran, 2004). A study proved that argumentation activities affected scientific conceptual change (Jimenez-Aleixandre and Pereiro-Munoz, 2002; Von Aufschnaiter et al., 2008) and constructed critical and systematic thinking (Kuhn, 2007). Other researchers also suggested that the learning process that trains to argue scientifically can build concepts, explanations, models, theories, and students' reasoning about scientific knowledge (McNeil, 2011; Sampson and Gerbino, 2010; Venville, 2010). Further, a positive relationship between the mastery of the ability to argue and the achievement of scientific knowledge occurs (Aydeniz, 2012; Cetin, 2014). All these empirical studies have asserted how scientific argumentation is essential to underpin all aspects of science learning.

This present study placed scientific argumentation as an activity infused in reading activities and evaluation to consider how students construct their knowledge. Like most researchers in science education, we used Toulmin's Argumentation Pattern (Toulmin, 2003) to train argumentation activities and to evaluate argumentation skills. This pattern consists of four elements: claims, data, explanations, and supports. A claim is a statement that is put forward for general acceptance. Data is a collection of facts that specifically support the truth of the claim. A warrant is an explanatory sentence that connects the claim with the facts presented. Support is a generalization that underpins the validity of the claims, data, and explanations put forward. Support commonly includes aspects of applicable theory, law, or general concepts. Despite providing an opportunity to construct knowledge, the argumentation activities in the context of reading activities also aim to reduce students' misconceptions of static electricity concepts.

We have known that misconceptions come from perception and cognitive structuring of everyday lives both physical and social that gradually shape an empirical knowledge of science (Moreira & Greca, 2003; Martinez-Borroguero et al., 2013). Consequently, when these processes fail to be constructed, students seem to inconsistently relate general theories to physical realities investigated. In the context of the research, the emergence of problems to drive argumentation activities in science reading activities aims to emerge cognitive conflict in students' minds—students here construct new knowledge by reading texts to obtain data, theories, and laws of the specific content. They write them in form of written arguments in columns of evidence from the texts. What we wish from these activities is students can replace the existing concepts with scientific theories to link the new propositions to their conceptual frame. Finally, conceptual changes occur and this process leads to reducing misconceptions.

Method

Research Design

This study uses a quasi-experimental method with a non-equivalent control group design (Robson & McCartan, 2016). We set an experimental group and a control group. A teacher who is a researcher ran the learning process using reading activities. The experimental group utilized a modified AG (infused argumentation activities) while the control group used unmodified AG as reading strategies. We here gave a pretest to all groups to investigate initial argumentation skills and identify students' initial misconceptions and posttest using the same problems to see argumentation skills and students' initial misconceptions after the learning process.

Participants

Participants in this study were 72 college students (aged 18-20 years) who were prospective science teacher students at one state university in Indonesia. They take lectures for eight semesters (4 years) to learn about science concepts and pedagogy to become science teachers. We used this study in the fourth semester when the students learn fundamental physics. They were divided into two groups; an experimental group (2 males and 34 females) and a control group (4 males and 32 females) consisting of 36 students respectively. All students participated to follow the pretest, treatment, and post-test.

Data Collection and Analysis

*Misconception Test***.** We measured students' misconceptions using a three-tier test instrument developed by the researcher (Appendix 1). The first tier is a choice of yes/no or true/false answers. The second tier is a reason answered freely by students and the third tier is a choice of confidence in answering (sure/not sure). We developed the test consisting of nine questions by adopting misconception topics of static electricity from another research (Muthiparaparampil, 2012). Our analysis reveals that the texts taken from textbooks encompassed an explanation of these misconception topics (see Table 1). We then tested the instrument on 60 prospective science teacher students who had already taken fundamental physics and calculated the reliability value (0.78). In addition, three experts

Table 1: Misconception topics (Muthiparaparampil, 2012)

Codes	*Misconception topics*
M1	The phenomenon of static electricity will only occur at low voltage
M2	There is only one charge contained in an object and depends on the type of charge on the object
M3	The object is neutrally charged, has neither a positive nor a negative charge
M4	A charged object will lose/gain electrons when in contact with an uncharged object until the charged object becomes neutral
M5	The electric field is real
M6	A certain amount of electric field on an electric charge
M7	The effect of the electric field is only at the point where the electric field line is drawn
M8	The phenomenon of static electricity is always caused by the friction of two objects
M9	Two objects with different amounts of charge will interact with each other with an electric force of different magnitude, proportional to the magnitude of the charge

in physics education who researched misconceptions judged the content validity of instruments and they valued that the instruments were appropriate to identify misconceptions.

We here made a category by following Arslan (2012) to analyze students' answers (see Table 2). We then scored each category: one for Scientific Knowledge (SK) and zero for other categories. The next stage is to compare the score of pre-tests with post-test for each misconception obtained. Finally, we tested a significant difference of whole scores of students' answers between the experimental and control group.

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Student Survey. We developed a survey (Appendix 2) to investigate how the argumentation skills of participants improved before and after the intervention. Development of assessment of argumentation skills refers to the methodology developed by other researchers (Venville & Dawson, 2010; Cetin, 2014). They developed an assessment to identify the scientific quality and complexity of the arguments. Here, we used TAP as a written argument model when students respond or answer the questions in the survey. We then scored students' written arguments based on the level of completeness of arguments. The maximum score here was 4 and the minimum score was 1; this occurs because the survey used one item test. One researcher scored and evaluated the arguments to each level by analyzing the completeness and scientific quality of

Table 2: Category of students' answers

First-tier	*Second-tier*	*Third-tier*	*Categories*	
Correct	Correct	Certain	Scientific knowledge	SK
Correct	Incorrect	Certain	Misconception (false positive)	Mis
Incorrect	Correct	Certain	Misconception (false negative)	
Incorrect	Incorrect	Certain	Misconception	
Correct	Correct	Uncertain	Lucky guess	LG
Correct	Incorrect	Uncertain	Lack of knowledge	LK
Incorrect	Correct	Uncertain	Lack of knowledge	
Incorrect	Incorrect	Uncertain	Lack of knowledge	

Table 3: Level of written arguments based on the completeness of the organs

Level	*Description*	*Example of Student Answers*
Level 1	Only claims made	Yes, I agree. I disagree. I agree that the first object will have less repulsion.
Level 2	Compile claims and data	I agree (claim), the magnitude of the electric force acting on a charged object is influenced by the magnitude of the charge (data). I disagree; both objects should have the same magnitude of repulsion (claim). The electric force acting on a charged object is caused by the interaction between the two charged objects at a certain distance (Data).
Level 3	Compile claims, data, and warrants	I agree (claim) that the two objects will get different forces depending on their charge (data). The first object has a greater charge to give a greater repulsion to the second object (warrant). I disagree if the two work different repulsion styles (claims). The two charged objects will repel each other with the same magnitude of repulsion but in opposite directions (data) since the force acting on both the first and second objects results from the interaction between the two objects (warrant).
Level 4	Compile claims, data, warrants, and backing	I disagree (claim). The magnitude of the repulsive force acting on the two objects must be the same, only the direction is different (data). The first object will act as an offensive force to the left due to interaction with the second object. The second object will act repulsive force to the right due to interaction with the first object. The resulting repulsive force, both acting on the first and second objects, results from the interaction between the two objects (Warrant), following Coulomb's law, F (Q1Q2)/r2. Based on the mathematical equation, because there is no influence of other objects (other than the two objects), the forces acting on the two objects are both the result of the interaction of the two objects. Hence, the magnitude is the same (backing).

Table 4: Level of arguing skills based on scientific quality of arguments

Level	*Description*	*Example of Student Answers*
SA1 (*Scientifically acceptable*)	Fully correct answer	I disagree. The repulsive force will act on both objects with the same magnitude but in different directions. The first object acts as a repulsion to the left due to interaction with the second object. In contrast, the second object acts as a repulsion to the right due to interaction with the first object. Based on the picture, because there is no influence from other (charged) objects other than the two objects, the force acting on both is the force generated by the interaction between the two objects only. Therefore, the magnitude of the force acting on the two objects is the same, according to the equation: F (Q1Q2)/r2.
SA2 (*Scientifically acceptable*)	Partially correct answer	I do not agree. According to Coulomb's law, the force acting on object 1 is equal to the force acting on object 2. The two objects interact with each other.
SU1 (*Scientifically unacceptable*)	Incorrect scientific knowledge	Yes, I agree. The two objects will certainly get a different repulsion according to the amount of charge of the objects interacting. The first object has a greater charge to exert a greater repulsive force on the second object.
SU2 (*Scientifically unacceptable*)	Irrelevant Answer/ explanation	I disagree because the magnitude of the repulsion depends on the type of object. We know that electrical properties are identical to magnetic properties.
WE (*Without explanation*)	Answer without explanation	Yes, I agree. I do not agree. I agree that the first object will have less repulsion.

Table 5: Learning process in each group of study

Group	*Content*	*Students' activities*
Experimental group	Electric charge, Coulomb's law, electric field, application of static electricity	• Respond all statements in modified AG through reading activities • Do explicit argumentation activities by creating written arguments using TAP model for each problem provided in modified AG trough reading activities • Discuss their answers in classroom discussion
Control group	Electric charge, Coulomb's law, electric field, application of static electricity	• Respond all statements in original AG through reading activities • Discuss their answers in classroom discussion

the proposed arguments. To see the consistency of evaluation, two experts that have expertise in argumentations evaluated 20% of total written arguments. The result of this reliability test was consistent (0.85) and then the researcher discussed with experts for some different results of the evaluation. Some examples of students' written arguments can be seen in Table 3 and Table 4.

Classroom intervention

We intervened in two groups by implementing modified and original AG (Appendix 3) for four meeting (90 minutes for each meeting). There were three stages in how the intervention was conducted for each group. First, the lecturer opens the lesson by introducing a few concepts to be learned. Second, the lecturer provides text and worksheets in the form of modified AG for the experimental group and original AG for the control group. Third, the lecturer guides the discussion to discuss students' answers in filling AG during reading activities. We here used a physics textbook entitled "Physics: principles with applications" (Giancoli, 2016) as text resources. All texts used have been translated into the Indonesian language and have been reviewed by linguists. This text was chosen because it contains appropriate content to topics of misconception in static electricity. The different intervention clearly can be seen in Table 5.

Findings

Reduction of the misconceptions

Because the data were not normally distributed, we used the Mann-Whitney U test to examine the significant difference of pretest to pretest of achievement of scientific concept acquisition between experimental and control groups. The result of the test shows that there is no significant difference among two groups (Mean Rank (exp) = 34.46; Mean Rank (cont.) = 38.54; n=36; $z = -0.911$; $p > 0.05$). Meanwhile, testing posttest to posttest using the same statistical tool shows a significant difference in the achievement of scientific concept acquisition (Mean Rank (exp) = 34.46; Mean Rank (cont.) = 38.54; n=36; $z = -4.859$; $p < 0.05$). Thus, students in the experimental group have better scores post-test than those control group. In addition, to analyze the significant difference between pretest to posttest, we examined these scores for each group. Our analysis found that both experimental group ($z = -5.273$; $p < 0.05$) and control group ($z = -5.268$; $p < 0.05$) showed significant difference between pretest and posttest. We finally show detailed information of achievement of scientific concept acquisition in Table 6.

Although we could see the percentage of all categories in Table 6, we keep in our mind that our analysis focused on the reduction of students' misconceptions on the experimental and control groups. Before the intervention, the highest percentage of students in the experimental group experienced misconceptions in M_6 (63.9%) whilst the lowest percentage of students experienced misconceptions in M_2 (13.9%). Further, we also observed five concepts in which students were dominant to experience misconceptions were M_6, M_4, M_7, M_9, and M_1; the others are still below 45%. Interestingly, providing argumentation activities in modified AG have eliminated several misconceptions. There were no students experiencing misconceptions in M_2, M_3, M_5, and M_8; below 15% of students still experienced misconceptions for several concepts that were M_7, M_6, M_4, M_1, and M_9. In the context of the control group, before the intervention, we observed that the highest percentage of students was a misconception in M_7 (55.6%) whilst the lowest percentage of students was a misconception in M_2 (13.9%). The use of original AG as a reading strategy has contributed to reducing misconceptions. Unfortunately, some students still experienced misconceptions: the highest percentage was in M_9 (30.6%) and the lowest percentage was in M_2 and M_3 (2.8%).

In addition, we observed another finding that reduction of misconceptions in experimental and control groups

Table 6: Percentage of misconceptions in experimental and control group

		SK (%)		*Mis (%)*		*LG (%)*		*LK (%)*	
Codes		*Exp.*	*Cont.*	*Exp.*	*Cont.*	*Exp.*	*Cont.*	*Exp.*	*Cont.*
M1	Pretest	11.1	13.9	47.2	44.4	13.9	8.30	27.8	33.3
	Posttest	86.1	66.7	8.30	22.2	0.00	2.80	5.60	8.30
M2	Pretest	27.8	33.3	19.4	13.9	22.2	16.7	30.6	36.1
	Posttest	94.4	83.3	0.00	2.80	0.00	2.80	5.60	11.1
M3	Pretest	33.3	27.8	13.9	19.4	8.30	13.9	44.4	38.9
	Posttest	97.2	86.1	0.00	2.80	0.00	2.80	2.80	8.30
M4	Pretest	8.30	11.1	61.1	52.8	5.60	2.80	25.0	33.3
	Posttest	88.9	69.4	8.30	22.2	0.00	0.00	2.80	8.30
M5	Pretest	13.9	16.7	25.0	27.8	8.30	2.80	52.8	52.8
	Posttest	94.4	77.8	0.00	8.30	0.00	0.00	5.60	13.9
M6	Pretest	5.60	8.30	63.9	52.8	5.60	2.80	25.0	36.1
	Posttest	88.9	69.4	8.30	22.2	0.00	0.00	2,80	8.30
M7	Pretest	8.30	11.1	47.2	55.6	8.30	5.60	36.1	27.8
	Posttest	88.9	75.0	5.60	19,4	0.00	0.00	5.60	5.60
M8	Pretest	13.9	11.1	41.7	33.3	5.60	8.30	38.9	47.2
	Posttest	97.2	8.60	0.00	11.1	0.00	0.00	2.80	8.30
M9	Pretest	5.60	8.30	52.8	47.2	2.80	8.30	38.9	36.1
	Posttest	80.6	58.3	13.9	30.6	0.00	0.00	5.60	11.1

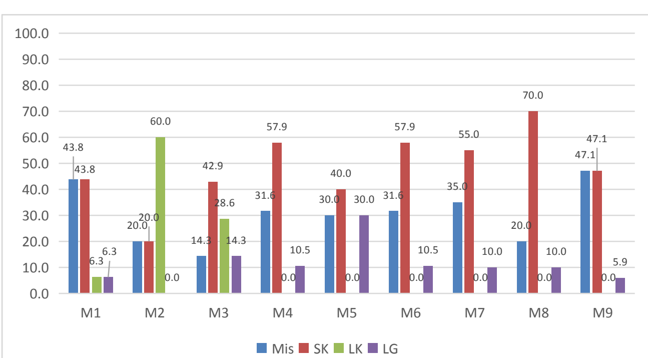

Fig. 1. The shifting of the misconceptions in control group

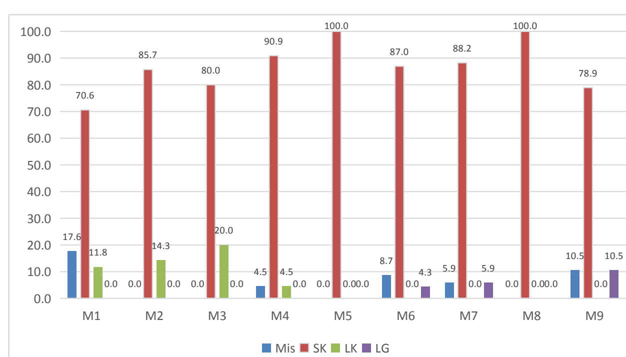

Fig. 2. Shifting of the misconceptions in experimental group

Table 7: Percentage of students' argumentation skills (complete organs)

	Level 1 (%)		*Level 2 (%)*		*Level 3 (%)*		*Level 4 (%)*	
	Exp.	Contr.	Exp.	Contr.	Exp.	Contr.	Exp.	Contr.
Pretest	16.7	13.9	69.4	61.1	8.30	16.7	5.60	8.30
Posttest	0.00	8.30	22.2	63.9	41.7	19.4	36.1	8.30

Table 8: Percentage of students' argumentation skills (scientific arguments)

	SA1		*SA2*		*SU*		*IA*		*NE*	
	Exp.	*Contr.*	*Exp.*	*Contr.*	*Exp.*	*Contr.*	*Exp.*	*Contr.*	*Exp.*	*Contr.*
Pretest	8.30	11.1	13.9	22.2	50.0	41.7	11.1	11.1	16.7	13.9
Posttest	44.4	16.7	35.1	44.4	16.7	25.0	2.80	5.60	0.00	8.30

aligned with the improvement of the number of students understanding concepts scientifically. Our analysis revealed that the experimental group had a better misconception shift than the control group (see Figure 1 and Figure 2). For instance, 70%-100% of students in the experimental group understood physics concepts scientifically although a few students were still categorized LK for concepts M_1, M_2, M_3, and M_4; the others were still classified as LG for concepts M_6, M_7, and M_9. Further, the different context occurs in the control group in which almost all students experiencing misconceptions changed their understanding of some concept being SK. Although there were shifting misconceptions to scientific knowledge, 10%-47% of students were still misconceptions from concept M_1 to M_9. This evidence asserted that some students changed their conceptions from misconceptions to LK on M_1, M_2, and M_3; the others just change their misconceptions to LG in almost all concepts except M_2.

The improvement of argumentation skills

Our analysis found that all data of written arguments were not normally distributed. For this reason, we employed the Mann-Whitney U test to examine the significant difference of pretest to pretest between experimental and control groups. The finding revealed that no significant difference occurred (Mean Rank (exp) = 34.44; Mean Rank (cont.) = 38.56; n = 36, z = -0.985, $p > 0.05$). Meanwhile, we revealed that scores of posttests to posttest between experimental and control group differed significantly (Mean Rank = 26.53, n = 36, z = -4.308, $p < 0.05$). Further, using Wilcoxon Sign Rank test we found that a significant difference of pretest to posttest in experimental group occurred (z = -4.777, $p < 0.05$); no significant difference happened in control group (z = -1.732, $p > 0.05$). These results indicate that the argumentation activities in modified AG influence the development of students' written arguments.

We then do the next analysis by elaborating the completeness of students' written arguments (Table 7). We here found that more than 60% of students in all groups has similar argumentation skills before the learning process in which they dominantly proposed arguments in level 2. This means they just could propose a claim supported by data. Providing argumentation activities to students proved that students in the experimental group had better skills in proposing arguments than those control group. A high percentage of changes of level arguments occurs, for instance, just a few students were in level 2 (22.2%) if compared with previous data (69.4%). The positive changes then occur for level 3 and level 4 in which two-fifth of students could achieve level 3 and slightly over one-third of students could achieve level 4. In contrast, low changes occur in level 2 and level 3 in the control group in which no change in level 4 occurs.

We finally analyzed students' written arguments based on the scientificity of the concepts (Table 8). Data before the intervention showed that domination of students in all groups proposed arguments in incorrect scientific knowledge (SU). The use of argumentation activities in modified AG becomes a bridge on how students construct their conception of concepts correctly. The high change of acquisition of scientific concepts occurred in students in the experimental group rather than the control group. Almost 45% of students in the experimental group are able to propose fully correct answers or scientific written arguments. In contrast, students in the control group are dominantly able to propose partial correct answers (44.4%) in the context of the written arguments.

Discussion

Our discussion focused on explaining two major questions. First, how explicit argumentation activities in science reading activities could reduce students' misconception of science concepts. Second, we aim to discuss how explicit argumentation activities in science reading activities could develop or improve students' argumentation skills. Our findings clearly depicted that reduction of students' misconceptions occurred between two groups but the high reduction could only occur in the experimental group. The next findings depicted that explicit argumentation activities in science reading activities contributed to the high improvement of argumentation skills although we realized that science reading activities themselves contributed to the acquisition of scientific concepts in two groups of study.

Reduction of students' misconceptions occurs because students in all groups reconstruct their conceptions of specific knowledge through reading activities. This aligns with other findings of the research that reading activities in science learning contributed to the acquisition of science concepts (Cano, 2014; Romance, 2017; Probosari, 2018; Rojas, 2019). In this study, the new specific knowledge was reconstructed through several activities in pre, during, and after reading. Pre-reading plays a role as a stimulus for students to reactivate what they have experienced or understood related to statements provided. To prove whether their conceptions are true, they verify them in the texts; this activity attempts to link what they knew to new knowledge (Pegg & Adams, 2012; Fenty, 2019; Rojas 2019). The difficulty of this activity is when students should find the texts that have the same meaning as presented in the statements but in different contexts. The success of this activity leads to meaningful learning so that students could reduce their misconceptions.

The following discussion is to reveal why explicit argumentation infused to science reading activities in the experimental group could reduce or eliminate better some misconceptions than those control group. As we knew that to eliminate or reduce students' misconceptions, the students should replace their existing conceptions using new concepts so the new propositions link to their conceptual frames. Argumentation activities here provided the problems functioning to stimulate existing conceptions in students' minds. Proposing written arguments is a crucial activity because students attempt to understand new concepts by confirming their conceptions via propose claim. To strengthen their confirming process, students have to look for data and reasoning to support them from the texts provided. Actually, we believed that the variability of difficulty of texts affects the success of the students in the acquisition of new concepts by constructing written arguments; that is why some students could eliminate their misconceptions but the others did not because they succeeded to link new propositions to their existing conceptual frames; at the same time, students have eliminated their misconceptions. These our arguments aligned with findings of the other research that argumentation activities in science learning have driven students to build concepts, explanations, models, theories, and students' reasoning about scientific knowledge (Aydeniz et al., 2012; McNeil, 2011; Sampson & Gerbino, 2010; Venville, 2010; Jimenez-Aleixandre, 2002). That is why the science learning process should provide opportunities to practice and learn about scientific argumentation because they facilitate the construction of meaning that leads to meaningful learning so misconceptions can be avoided (Duschl, 2008).

More importantly, our discussion focused on explaining why explicit argumentation activities improved the completeness of argumentation structures or organs in the experimental group. We look at this as a common situation in which students train regularly from one meeting to another meeting. For instance, at the first meeting when students learn concepts of electrical charges, they should respond to several problems in form of written arguments by proposing claims, data, warrants, and backings; the same situation happened in other meetings. This means that the frequency of exercises caused students to have good respond in proposing written arguments comprehensively. This argument is in line with some other researchers' arguments that the science learning process involving explicit argumentation activities could enhance significantly students' argumentation skills although the activities occurred within a short time (Venville & Dawson, 2010; Cetin, 2014). Although this argument is rationale enough, we are interested in discussing this finding from the acquisition of scientific knowledge perspectives.

In the acquisition of scientific knowledge considerations, we evaluate that the completeness of argument structures or organs is based on several reasons. First, when students were engaged in argumentation activities to create responses to problems, this situation is not only to propose convincing arguments to take a certain position in written arguments but also deepens students' understanding of the correct concept in the process (Kuhn, 1992). Secondly, when students train to propose arguments, they attempted to link claims, data, warrants, and backing. This activity considerably enhances and extends the organization of knowledge which leads to better recall and understanding on subsequent test occasions (Mean & Voss, 1996). In the other words, when students were involved to respond to new problems in the survey, they just need to reorganize what they understood to respond to problems that have the same meaning in the new context. That is why students propose written arguments comprehensively. This aligns with a finding of another research that the better students' understanding of scientific concepts the easier they construct arguments (Clark &Sampson, 2008; Glassner et al., 2005).

Finally, we believed that this research has two implications in science education research: theoretical and practical implications. In the theoretical contexts, this present adds empirical evidence that integration of argumentation activities in reading activities could reduce students' misconceptions and construct students' argumentation skills. In the practical contexts, the effectiveness of the learning engaging argumentation activities in science reading activities has become proof that this activity can be implemented in diverse subjects and learning processes. Science teachers and educators could apply this as an alternative way to bridge meaningful learning beyond regular activities such as laboratory activities.

Conclusion

We concluded several essential points from the findings of our research. First, a decrease in students' misconceptions occurs in both the experimental and control groups. This is as a result of reading activities carried out in both groups. However, the involvement of argumentation activities in reading activities in the experimental group resulted in a better reduction of misconceptions. In addition, our research findings also provide evidence that the intervention provided in the learning process can improve students' argumentation skills, both in terms of the completeness of the organs and the scientific quality of the arguments. Our research findings also provide evidence that practically teaching science does not always have to be done with laboratory activities in the lab. Science learning involving reading activities can positively affect the achievement of science learning outcomes when conducted precisely. Our research has provided evidence of how science reading activities in science learning successfully improved argumentation skills and reduced misconceptions.

Limitation and Suggestion for Future Work

We considered that our study has three limitations. First, we conducted this study on a small population, so the generalization process of our research findings is limited. Second, the misconceptions that we attempt to eliminate focus on concepts of static electricity. Third, the arguments we practice are written arguments, not oral and dialogue. Therefore, several things need to be done for further research: enlarging the population so that the generalization process of research results becomes wider in scope; conducting further research on other topics that are prone to causing misconceptions; carrying out further innovation so that the argumentation training process is also carried out verbally and in dialogue. Researchers here are also able to analyze the development of students' argumentation skills orally whether it provides the same result as it is done in writing to the acquisition of science concepts.

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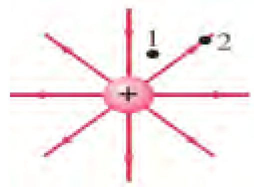
Appendix

Appendix 1. Static Electricity Misconception Test

1. Static electricity is closely related to everyday life, as is dynamic electricity. However, static electricity will only occur at low voltages. In your opinion, is this true?
   ☐ Yes
   ☐ No
   Explanation:
   Are you sure about your answer?
   ☐ Sure
   ☐ Not sure
2. There is an object that is positively charged. In your opinion, do all parts of the object contain a positive charge?
   ☐ Yes
   ☐ No
   Explanation:
   Are you sure about your answer?
   ☐ Sure
   ☐ Not sure
3. If an object has no charge (neutral), is there no negative charge on the object?
   ☐ Yes
   ☐ No
   Explanation:
   Are you sure about your answer?
   ☐ Sure
   ☐ Not sure
4. "There are two objects, A and B. Object A has a charge, while object B has no charge. In your opinion, is it true that if objects A and B touch each other, object A will lose electrons or will gain electrons until object A becomes neutral?"
   In your opinion, is this statement true?
   ☐ Yes
   ☐ No
   Explanation:
   Are you sure about your answer?
   ☐ Sure
   ☐ Not sure
5. Do you agree that the electric field is a real straight line?
   ☐ Yes
   ☐ No
   Explanation:
   Are you sure about your answer?
   ☐ Sure
   ☐ Not sure
6. Pay attention to the following statement!
   "In a charged object, there are electric field lines around a certain amount of charge."
   In your opinion, is this statement true?
   ☐ Yes
   ☐ No
   Explanation:
   Are you sure about your answer?
   ☐ Sure
   ☐ Not sure
7. Look at the following picture.

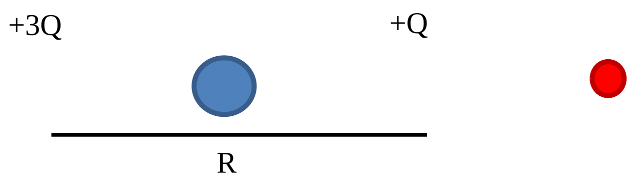


   The image above describes the direction of the electric field produced by a positively charged object. Do you think that at point 1, the electric field will be 0?
   ☐ Yes
   ☐ No
   Explanation:
   Are you sure about your answer?
   ☐ Sure
   ☐ Not sure
8. Pay attention to the following statement!
   "The symptoms of static electricity are always caused by the friction of two or more objects."
   In your opinion, is this statement true?
   ☐ Yes
   ☐ No
   Explanation:
   Are you sure about your answer?
   ☐ Sure
   ☐ Not sure
9. In a container, there are two objects, A and B, which have the same charge. Object A has a smaller amount of charge than object B. Object A will attract object B with a smaller force than object B when it attracts object A.
   ☐ Right
   ☐ Wrong
   Explanation:
   Are you sure about your answer?
   ☐ Sure
   ☐ Not sure

Appendix 2

Students' Survey

Look at the following picture!



The picture above describes two objects with different charges separated by a distance R. The first object has a charge of +3Q and the second object is +Q. Because they have the same charge, the two objects will produce an electric force in opposite directions, causing them to repel each other.

Possible events:
The first object will get a leftward repulsion due to the charge on the second object, and the second object will get a rightward repulsion due to the charge on the first object. Since the charge on the first object is greater than the second object, the right repulsion force on the second object caused by the first object will be greater than the left repulsion force on the first object as a result of the charge on the second object.

Do you agree with that? Explain!

Appendix 3

The anticipation guides strategy

The Worksheet Using Anticipation Guides Strategy in the Experimental Group

Statement	I think it's… True	I think it's… False	The text says that it's… True	The text says that it's… False	Evidence from the text (Pg. & No.)
Statement 1 (key concept)					(without proposing argument)
Statement 2 (key concept)					(without proposing argument)
… etc					
Problem Statement 1 (proposing argument)					Claim: Data: Warrant: Backing: So that ….
Problem Statement 2 (proposing argument)					Claim: Data: Warrant: Backing: So that ….

The Worksheet Using Anticipation Guides in the Control Group

Statement	I think it's … True	I think it's … False	The text says that it's … True	The text says that it's … False	Evidence from the text (Pg. & No.)
Statement 1 (key concept)					(without proposing argument)
Statement 2 (key concept)					(without proposing argument)
… etc					