The Argumentation Skills of Junior High School Students on Physical Changes and Chemical Changes

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Abstract. The purpose of this study is to investigate the improvement of junior high school students’ argumentation skills on the topic of physical changes and chemical changes. The design of this study used one group pretest-posttest design. Data were then analysed using descriptive statistics to describe the students’ argumentation skills and inferential statistics to examine students’ improvement. The results of the research showed that students' argumentation skills on some indicators were successfully applied: examining claims, showing evidence, making reason, and arranging contra-argument after joining the learning model which consisted of five phases, namely (1) orientation, (2) exploration, (3) pre-argument, (4) arguments and contra-argument, and (5) reflection on limited trials and extensive trials.

1. Introduction

Osborne [1] stated that the goal of science learning in the 21st century is more emphasized on the development of critical thinking skills. Developing critical thinking skills is one of the objectives of science learning in junior high schools in the 21st century [2]. This is also consistent with one of the goals to be achieved in science subjects in junior / MTs based on the Curriculum 2013 which is to develop critical thinking skills [3].

According to Paul [4], argumentation skills are part of critical thinking skills. Another similar opinion by Marttunen, Leena, Litosseliti, & Lund [5] revealed that the skill of argumentation is one of the important competencies required by students because argumentation can develop critical thinking skills. In a similar vein, Liliasari [2], argues that the most fundamental skill in developing critical thinking skills is argumentation skills.

Argumentation skill is important to be trained in the science-learning process. According to Osborne et al. [1], this is because: 1) scientists are found to get used to arguing on certain phenomena to develop and improve their scientific knowledge, 2) community also argue in the process of scientific debate, and 3) students also argue in the learning process to improve their understandings. This opinion is supported by Erduran [6] stating that argumentation skill is an important ability to be trained in science learning. Furthermore, there are three factors that lead to important argumentation skills in science learning: it can improve high-level thinking processes through social interaction activities; train students in constructing scientific arguments supported by relevant evidence through the process of learning, tasks, and modeling of teachers, and improve students' conceptual understanding. Based on these
opinions, teachers need to practice argumentation skills for science learning [7]. This is because students who are trained in argumentation skills can improve their argumentation skills.

Several studies have been conducted to find a link between argumentation skill exercises and students' argumentation. Science teaching on the topic of acid and base based on argumentation significantly influenced students' argumentation skills by Sagir & Kihc [8]. Groups of students who participated in the teaching model were better in terms of argument ability compared with the group of students following the conventional learning. The results of this study are relevant to the results of Chen, Lin, Hsu, & Lee [9] research which found that students who attended physics-oriented learning had better argument ability than students who received conventional learning. The same thing was expressed by Khisfe [10] finding that students who are able to construct arguments had better argumentation skills.

The learning model that trains the argumentation skills in this research is the innovation of the QA (Question Argumentation) model developed by Chin and Osborne [11]. The innovation is done by considering learning strategies to develop students' argumentation skills in science learning developed by Simon, Erduran, & Osborne [12]. The results of research conducted by Simon et al. [12] found that a strategy of learning supporting argumentation skill in a science topic completed with six major steps in learning can significantly develop students' argumentation skills. Another result that is also obtained is the reflection step is an important step in the learning of argumentation skills. This is because the reflection step can provide an opportunity for teachers to provide feedback on the learning process and the results of the preparation of arguments by students. The results of research that have been obtained Simon et al. [12], were further developed by Dawson & Venville [13] on biology subjects. The main results of this study were derived from the development of the strategies: (1) providing a step to find evidence used in strengthening the argument, (2) provoking a counterargumentary step that requires students to retain arguments and draw up opposing arguments. Based on the advantages and disadvantages of the QA learning model and considering the argumentative learning strategy proposed by Simon et al. [12] was developed further by Dawson & Venville [13], this study resulted in a learning argumentation model that has a syntax consisting of five phases, namely (1) orientation, (2) exploration, (3) pre-arguments, (4) arguments and counterargument, and (5) reflection to improve junior high school students' argumentation skills.

2. Method

2.1. Research Design

This research is a pre-experimental quantitative studies with one-group pretest-posttest design [14]. The subjects of this research were the junior high school students of class VII in the 2016/2017 academic year at junior high school 14 Surabaya. The total number of the subjects was 30 students. This research was conducted for six meetings with the allocation time each meeting 3 x 50 minutes. The diagram of the one-group pretest-posttest design is shown in Figure 1.

|          | O₁ | X   | O₂ |
|----------|----|-----|----|
| Initial test |    |     |    |
| Treatment  |    |     |    |
| Final test |    |     |    |

Figure 1 Pretest-posttest one-group design (Fraenkel & Wallen, 2009)

Note:
O₁ : Initial argumentation skills testing for concepts physical changes and chemical changes
X : Treatment: Model of argumentation skills learning
O₂ : Final test, argumentation skills for concepts physical changes and chemical changes

Before the model of argumentation skills learning is applied, a preliminary test was firstly conducted to see the students' argumentation skills. The model of argumentation skills learning is applied for three
learnings, then a final test is conducted to look at differences in student's argumentation skills between before and after learning applying the model of argumentation skills learning.

2.2. Data analysis on students’ argumentation skills
Preliminary test data and student final tests were further analyzed using inferential statistical tests. The score level for claims and evidence is based on the evidence shown in support of the claim. The reason-scoring level is based on the logical reasons the students constructed to explain why the proposed evidence can support the claim and the level of the contra-argument scores based on whether the students could set up reasons that support such contra-arguments as proposed by the Zohar & Nemet [15], Acar & Patton [16], and Supeno [17]. The final rubric is used as shown in Table 1.

| Score | Description                                      |
|-------|--------------------------------------------------|
| 0     | No claim                                         |
| 1     | Claim exist, but wrong                          |
| 2     | Correct claim                                    |
|       | **Existence of Evidence**                        |
| 0     | No evidence                                      |
| 1     | Evidence exists and supports the claims (one correct evidence) |
| 2     | Evidence exists and supports the claims (two correct evidence) |
|       | **Existence of Reasons**                         |
| 0     | No reason                                        |
| 1     | Reason exist, but does not align with evidence, and incorrect |
| 2     | Reason exist aligning with evidence, correct but incomplete |
| 3     | Reason exist aligning with evidence, correct and complete |
|       | **Existence of Contra-argument**                 |
| 0     | No contra-argument                               |
| 1     | Contra-argument exists, but incorrect            |
| 2     | Contra-argument exists and correct               |
| 3     | Contra-argument exists and correct, but incorrect reasons |
| 4     | Contra-argument exists and correct, correct reasons but incomplete |
| 5     | Contra-argument exists and correct, correct reasons and complete |

The statistical test used is the Wilcoxon Signed Ranking test (nonparametric) [18]. The hypothesis is tested as follows.

\[ H_0: \text{There is no difference in the student's argumentation skills before and after the learning applying model of argumentation skills learning.} \]
\[ H_1: \text{There is difference in the student's argumentation skills before and after the learning applying model of argumentation skills learning.} \]

In the testing, the hypothesis uses a significant level \( \alpha = 0.05 \). \( H_0 \) rejection criteria is based on T as follows.

- \( H_0 \) is accepted if \( T \geq T_\alpha \)
- \( H_0 \) is rejected if \( T < T_\alpha \)
3. Results and discussion

Table 2 Inferential statistical test on the limited trial

| Learning code | T-score | T-table | Decision       |
|---------------|---------|---------|----------------|
| L-1           | 0       | 151     | $H_0$ is rejected, $H_1$ is accepted |
| L-2           | 0       | 151     | $H_0$ is rejected, $H_1$ is accepted |
| L-3           | 0       | 151     | $H_0$ is rejected, $H_1$ is accepted |

Table 2 shows the result of Wilcoxon Ranking test from learning 1 to 3 (L-1, L-2, L-3), which indicates that the value of $T$-score < $T$-table with $\alpha = 0.05$. Therefore, $H_0$ is rejected, which means that the students' argumentation skills between pre- and post-learning that applying model of argumentation skills learning are not the same, in which case students who acquire argumentation skill-learning by applying model of argumentation skills learning have higher argumentation skills.

Table 3 Inferential statistical test on the extensive trial

| Learning code | Class A | Class B |
|---------------|---------|---------|
|               | T-score | T-table | Decision       | T-score | T-table | Decision |
| L-1           | 0       | 151     | $H_0$ is rejected, $H_1$ is accepted | 0       | 151     | $H_0$ is rejected |
| L-2           | 0       | 151     | $H_0$ is rejected, $H_1$ is accepted | 0       | 151     | $H_0$ is rejected |
| L-3           | 0       | 151     | $H_0$ is rejected, $H_1$ is accepted | 0       | 151     | $H_0$ is rejected |

Table 3 shows the calculation of Wilcoxon Signed Ranking test statistic in class A and class B which indicates that $T$-score < $T$-table with $\alpha = 0.05$. Therefore, $H_0$ is rejected. This means that students' pre- and post argumentation skills applying the model of argumentation skills learning in class A and class B are not the same. These results show that students on those three learnings (L-1, L-2, L-3) have better (high) argumentation skills. Thus, science learning that brings about argumentation abilities optimal, which in this case support the finding of Chen & She [19]; Sampson & Clark [21]; Zohar & Nemet [15]; Duschl & Osborne [7].

In the orientation phase, the strategy used to teach students to construct claims in this study is to use competing theories strategy. According to the strategy, students construct claims by choosing one of the statements of two controversial statements about the phenomenon to be debated [1,20]. Enhancement of student activity on the worksheet assessed by observers is to make claims using a competing theories strategy, to discuss the results of claims in limited trials and extensive trials. This is to illustrate that students have been able to construct claims as a first step in argumentation skills. This is why the ability to construct claims as an indicator of argumentation skills has improved from learning 1 to 3 after applying the model of argumentation skills learning.

In the exploration phase, the improvement of students' activity to explore concepts physical change and chemical changes, i.e. analyzing the information from the student's book, experimenting to obtain data that can be used as evidence to support the claim, discussing the data that has been
obtained to be used as evidence in the limited trial and the extensive trial, investigating evidence and showing evidence used to support the claim. This is what causes the ability to demonstrate evidence as one indicator of argumentation skills improved after the applying model of argumentation skills learning. In addition, the students’ abilities are found consistent with the opinions of Katchevich, Hofstein & Naaman [22] where students' argumentation skills can evolve by providing experimental opportunities to help students obtain empirical evidence that can be used in strengthening arguments. In addition to conducting experiments, proof-seeking activities can be undertaken by reviewing teaching materials [23].

Another argumentation skill assessed in this study is the ability to set up the reasons and the contra-argument. The improvement of student activity in drawing on reasons and arguments also occurs, proven by the student's ability to analyze claims, evidence, and reasons into a proper argument diagram, discuss the results of argument diagrams, and construct the counterargument (pre-argument stage). Students' ability to compose reasons and contra-arguments in limited trials and extensive trials is an illustration that students have been able to set up reasons and contra-arguments. This become an indicator of the improvement of argumentation skill after being engaged in the model of argumentation skills learning. The ability of the student in accordance with the opinion of Chin & Osborne [11] stating that students’ ability to make claims, show evidence, and make reasons can be drawn through the preparation of argument diagrams to produce a complete argument. Therefore, it can be concluded that students’ activities in analysing the claims, evidence, and reasons in an argument diagram and drawing up a counter-argument on applying model of argumentation skills learning can improve students' argumentation skills.

4. Conclusion

The results of this study suggest that there are significant differences in the skills of argumentation between before and after learning applying the model of argumentation skills learning on both the limited trial and the extensive trial. The syntax of the learning model consists of five phases, namely orientation, exploration, pre-arguments, arguments and counterargument, and reflection. There were also improvements of students’ argumentation skills in relation to indicators: making claims, showing evidence, preparing reasons and preparing a counter-argument.

5. References
[1] Osborne J, Erduran S and Simon S 2004 J. Sci. Edu. 6 915
[2] Liliasari 2009 http://file.upi.edu.
[3] Permendikbud Nomor 68 tahun 2013 tentang Kerangka Dasar dan Struktur Kurikulum Sekolah Menengah Pertama/ Madrasah Tsanawiyah.
[4] Paul R W 1992 J. Dev. Edu. 2 34
[5] Marttunen M, Leena L, Litosseliti L and Lund K 2005 J. Edu. Res and Eval. 4 365
[6] Erduran S and Maria P J 2008 Argumentation in Science Education. (London: Springer.)
[7] Duschl R A and Osborne J 2002 J. Stud. in. Sci. Edu. 3 39
[8] Sagir S U and Kihc Z 2012 Eurasian. J. Phys and Chem Edu. 2 139
[9] Chen J, Lin H, Hsu Y and Lee H 2011 J. Sci. Edu. 2 147
[10] Khise R 2012 J.Res in Sci Teach. 4 489
[11] Chin M and Osborne J 2010 J. The Learn. Sci. 2 230
[12] Simon S, Erduran S and Osborne J 2006 J. Sci. Edu. 2 235
[13] Dawson M V and Venville G 2010 J. Res. Sci. Edu. 2 133
[14] Fraenkel J R and Wallen N E 2009 How to design and evaluate resarch in education. 5th ed. (Boston: McGraw-Hill Companies)
[15] Zohar A and Nemet F 2002 J. Res in Sci Teach. 39 35
[16] Acar O and Patton B R 2012 J. Soc and Behvi Sci. 45 4756
[17] Supeno, Nur M dan Susantini E 2016 Model Pembelajaran Penyelesaian Masalah Argumentasi (PMA) untuk Meningkatkan Hasil Belajar Kognitif Produk, Kognitif Proses, dan Keterampilan Argumentasi Ilmiah Siswa SMK. Unpublished dissertation. PPS Unesa.

[18] Djarwanto 1991 Statistik Nonparametrik (Yogyakarta: BPFE Yogyakarta)

[19] Chen C H and She H C 2012 J. Edu Tech & Soc. 1 197

[20] Bell P and Linn M C 2000 Inter J. of Sci. Edu. 8 797

[21] Sampson V and Clark D 2011 J. Sci. Edu. 93 448

[22] Katchevich D, Hofstein A and Naaman R M 2013 J. Res in Sci. Edu. 43 317

[23] Wilson C D, Taylor J A, Kowalski S M and Carlson J 2010 J. Phys. Edu. 38 324