Student’s Scientific Argumentation Skills on Heat and Temperature

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ABSTRACT

The weak of students' scientific argumentation skills in lessons has been a concern, especially in applying concepts of heat and temperature. Although heat and temperature are related to daily activity, it doesn’t ensure that students have the correct concept. This study purposes to describe students' scientific argumentation skills on heat and temperature. This research was conducted on 11th-grade in mathematics and science students in Senior High School 4 of Malang. This study found that students' scientific argumentation skills on average were at level 2nd and level 3rd. In addition, we found three patterns of scientific argumentation skills: (1) correct claims and evidence are accompanied by support for the evidence provided, (2) correct claims but use incomplete evidence, and (3) correct claims but the evidence is given wrong. This result it is expected to be the attention of teachers to implement learning models that can improve students' scientific argumentation skills.

INTRODUCTION

The scientific argumentation skills is an inseparable part of learning physics concepts. Scientific argumentation skills one of the abilities that must behave by students (Ault et al., 2015). The learning process in the classroom should be able to train scientific argumentation skills (Eskin & Ogan-Bekiroglu, 2013; Osborne et al., 2004; Probosari et al., 2016). The good scientific argumentation skills can help students respond to phenomena in every day using the correct concept of physics.
Scientific arguments skills have characteristics than arguments used in every day. This difference is based on the components used in giving arguments. There are six components used simultaneously in delivering scientific arguments. These components include claims, data, warrant, rebuttal, backing, and qualifier (Lee et al., 2014; Toulmin, 2003). In arguing, one can use evidence to show whether an opinion is true or false (Wendra et al., 2012).

Claims or statements are used as the first step in giving scientific arguments. Claims submitted can be in the form of statements of support or objection to a scientific statement. Data is used to support statements that have been submitted previously. When the submitted data requires theoretical or empirical support, the warrant is used to strengthen the data provided. Warrants used are generally in the form of a hypothesis statement, so a backing is needed to provide a guarantee that the data provided is valid. The qualifier component used in clarifying the submitted claim can be scientifically accepted based on the appropriate concept. When the initial claim submitted has a refusal or objection from another person, then the rebuttal is used to corroborate claims made using scientifically accepted evidence (Hoyningen-Huene, 2018; Reiners et al., 2017).

The students’ scientific argumentation skills can be analyzed using the framework of Toulmin's Argumentation Pattern (TAP) (Toulmin, 2003). TAP is considered capable of identifying the scientific argumentation skills in understanding a physics concept. The scientific argumentation skills can be assessed and identified based on the complete use of interrelated components of scientific argumentation (Falk & Brodsky, 2014; Grooms et al., 2015; Lazarou et al., 2017).

Theoretically, the scientific argumentation skills is good if there are six constituent components used simultaneously (Demircioglu & Ucar, 2015; Siswanto et al., 2014). However, in practice it was found that students experienced difficulties in conveying scientific arguments. The results of the study show that the scientific argumentation skills is still relatively low (Asniar, 2016). Other studies also found that students were less able to give a rebuttal to a false statement (Muhajir et al., 2016). The weakness of students in providing scientific arguments is caused by the frequent students giving unreasonable reasons when asked to provide support or objections to a scientific statement (Soekisno, 2015). This lack of activity which aims to train the scientific argumentation skills is the main factor causing the weak scientific argumentation skills (Aisyah & Wasis, 2015; Mahardika et al., 2015).

The concept of heat and temperature is one of the physical concepts that occur in daily activity. Phenomena related to the concept of heat and temperature are often experienced directly by students. For example, when heating water, heat transfer by conduction, convection and radiation takes place in the event. In addition, the expansion concept is also often found in the installation of glass in classroom windows which are deliberately made loose. This study purposes to describe student’s scientific arguments skills on heat and temperature. The results of these findings are expected to be the basis for developing the learning process in the classroom.

METHODOLOGY

This research is quantitative descriptive methods. The subjects used in this study were students of 11th-grade in mathematics and science students (N = 63) in Senior High School 4 of Malang. Tests instrument using essay questions that have been tested...
for validity and reliability. After the test, students are then interviewed to clarification they answers. Based on validity and reliability analysis presented in Table 1.1.

Table 1. Analysis of Validity and Reliability of Test Instruments

<table>
<thead>
<tr>
<th>Number of questions</th>
<th>Validity* Value</th>
<th>Validity Criteria</th>
<th>Reliability Cronbachs’ Alpha</th>
<th>Reliability Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.741</td>
<td>Valid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.670</td>
<td>Valid</td>
<td>0.717</td>
<td>Reliabel</td>
</tr>
<tr>
<td>3</td>
<td>0.767</td>
<td>Valid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.648</td>
<td>Valid</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.01 level (2-tailed)

The assessment of scientific argumentation skills was carried out using the framework of the Toulmin’s Argumentation Pattern (TAP) developed by Lee, et al (2014). The validity of students’ scientific argumentation skills was analyzed based on the completeness and correctness of the use of scientific argumentation components. Components of scientific argumentation skills include claims, data, warrant, rebuttal, backing, and qualifier. Furthermore, students are grouped into five levels of scientific argumentation abilities presented in Table 2.

Table 2. Toulmin's Argumentation Pattern Framework (TAP)

<table>
<thead>
<tr>
<th>Levels</th>
<th>Descriptions</th>
<th>TAP Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Scientific claim</td>
<td>Claim</td>
</tr>
<tr>
<td>Level 2</td>
<td>Coordination between claims and evidence</td>
<td>Claim and data</td>
</tr>
<tr>
<td>Level 3</td>
<td>Reasonable coordination between claims and evidence</td>
<td>Claim, data and warrant/backing</td>
</tr>
<tr>
<td>Level 4</td>
<td>Modified, coordination between claims and evidence</td>
<td>Claim, data, warrant/backing, and qualifier</td>
</tr>
<tr>
<td>Level 5</td>
<td>Conditional, modified, and coordination between claims and evidence</td>
<td>Claim, data, warrant/backing, qualifier and rebuttal</td>
</tr>
</tbody>
</table>

Source: (Lee et al., 2014)

RESULT AND DISCUSSION
Distribution of the Skills Level of Student Scientific Arguments

Based on the results analysis of student answers related to the levels of scientific argumentation skills based on the average student answers presented in Table 1.3.

Table 3. Distribution of Scientific Argumentation Skills

<table>
<thead>
<tr>
<th>Levels</th>
<th>Total of Students</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>0</td>
<td>0,00</td>
</tr>
<tr>
<td>Level 2</td>
<td>26</td>
<td>41,27</td>
</tr>
</tbody>
</table>
From Table 3, it can be seen that the student dominant is still at level 2nd and level 3rd. This can be seen in the number of students at level 2nd as many as 26 students with a percentage of 31.27% and those at level 3rd as many as 32 students with a percentage of 50.79%. One of the reasons for this low level of student argumentation skills is the inability to conclude what has been revealed.

Distribution of Scientific Argumentation skills Level Based on Topics

Based on the results of student answers analysis related to the levels of scientific argumentation skills based on temperature and heat topics are presented in Table 1.4.

<table>
<thead>
<tr>
<th>Topics</th>
<th>Total of Students</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 3</td>
<td>32</td>
<td>50.79</td>
</tr>
<tr>
<td>Level 4</td>
<td>5</td>
<td>7.94</td>
</tr>
<tr>
<td>Level 5</td>
<td>0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>0</td>
<td>7</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Heat effect</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Azas Black</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Heat Transfer</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

From Table 4 on each topics tested the dominant students are still at level 2nd and level 3rd. The weakness of students’ scientific argumentation skills is not caused by the topic being studied. This weakness is caused because students have not been able to give conclusions on the statements and data that have been given. So that there are indications that this weakness is caused by students not accustomed to argumentation activities, so there needs to be a learning model that can involve students in argumentative discourse.

The Patterns of Student’s Scientific Argumentation Skills

Each student’s answers can provide a claim with evidence, but not all of students are able to provide support for the evidence presented and backing the answers given using appropriate physics concepts. The following are described in the interview results to a sample of randomly selected students.
Correct claims and evidence are accompanied by support for the evidence provided

This model is categorized based on the ability of students to provide complete reasons and give the right physical concepts for the statements given. Analysis of scientific argumentation skill is presented in Figure 1.1.

![Jawab](image1)

Figure 1. Analysis of First Pattern of Scientific Argument Pattern

Based on interviews, the student gave the correct claim, but the evidence given by the student was wrong. Students understand that heat is a form of substance, thus interpreting that heat can move. Student should interpret heat as energy flowing on objects that have a high temperature towards objects that have lower temperatures. The examples of students’ interview results.

**Instructed** : “Do campers feel the heat from the campfire?”
**Student** : “Yes, camp participants can feel the heat.”
**Instructed** : “Why can campers feel the heat?”
**Student** : “Because heat from a fire can drain the heat without having to touch.”
**Instructed** : “In your opinion, what concept is there in the event?”
**Student** : “The heat is received according to the concept of radiation.”
**Instructed** : “What is radiation?”
**Student** : “Radiation is heat transfer which doesn’t require intermediary media.”

Correct claims but use incomplete evidence

This model is categorized based on the lack of students' ability to give reasons for the statements given. The examples of students' interview results. Analysis of scientific argumentation skill is presented in Figure 2.

![Jawab](image2)

Figure 1. Analysis of Second Pattern of Scientific Argument Pattern

Based on interviews, student give the correct claim, but student don’t understand if the hand has touched one of the water, there will be a change in temperature on the surface of the hand. Thus it is difficult to distinguish the size of the temperature in other glasses. It's better to use a measuring device that has a scale like a thermometer. The examples of students’ interview results.

**Instructed** : “Does Andi sort the glass from high to low?”
Correct claims but the evidence given is wrong

This model is categorized based on the inability of students to provide complete reasons for the statements given. Analysis of scientific argumentation skill is presented in Figure 3.

Based on interviews, students can provide claims and evidence appropriately. In addition, students can also provide support for answers given using appropriate physics concepts. Students use the radiation concept to explain why camp participants can feel heat from a campfire. The examples of students' interview results.

Instructed: “What happens when the ice cream melts?”
Student: “The ice cream melts because it is affected by heat.”
Instructed: “How can heat melt the ice cream?”
Student: “The heat outside the store is higher and affects the form of ice cream.”

CONCLUSION

This study purposes to describe the students' scientific argumentation skills on heat and temperature. Based on the results, the dominant students are still at level 2nd and level 3rd, which is only able to give statements along with reasons and support. But it has not been able to give conclusions on the statements that have been disclosed. In addition, the weak of student argumentation skills is caused by students not yet accustomed to activities that involve of scientific argumentation skills in the learning process, so that students are not used to giving good arguments.

Based on interviews, we found three patterns of student answers about the scientific argumentation skills. The three patterns are (1) correct claims and evidence are accompanied by support for the evidence provided, (2) correct claims but use incomplete evidence, and (3) correct claims but the evidence given is wrong.

Based on the findings, it is expected that the learning carried out directs students to practice the scientific argumentation skills. Improvement of learning can be done by
choosing a learning model that has learning steps that can train the scientific argumentation skills.

REFERENCES


