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Analysis of scientific argument of vocational high school students on the topic of substance change

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Abstract. This study aims to see the ability of scientific argumentation of chemical analysis vocational high school students on the topic of changing the form of substances. This research is a qualitative descriptive study. The instrument used was a four-level multiple choice test with a validity value of 97% and a reliability of 0.83 consisting of 20 items related to the concept of changing the form of a substance. The research subjects were 173 vocational high school students majoring in chemical analysis. The results showed that the proportion of the ability of class X, XI and XII students in providing scientific arguments was 56%, 56% and 52%, respectively. These results are supported by students' conceptual understanding of topics that change the form of substances, namely students who understand well at 34.77%; misconception error 1 of 16.16%; misconception error 2 was 8.99%; misconception error 3 is 15.84% and those who do not understand the concept are 24.25%. From the results of the study it can be ignored that students have low scientific argumentation skills due to students' low conceptual understanding of the topic of changing the form of substances.

1. Introduction

Communication is one of the efforts that can be made to improve the quality of education in Indonesia. According to Doringin, the skills that must be emphasized on students in the 21st century are 4C skills, namely communication, critical thinking and problem solving, collaboration and creativity and innovation [1], [2]. One of the important aspects of communication is the ability of scientific argumentation. Scientific argumentation is a person's opinion about his thinking which is a fact, which requires the ability to think about scientific subjects by conveying and discussing his thoughts in writing or orally [3]. In general, scientific argumentation's ability consists of indicators of claims, evidence, and justification [4]. Scientific argumentation is the main source that underlies students in learning how to produce evidence, test and evaluate theories. In addition, scientific argumentation skills can also improve students' scientific literacy skills, so it is considered important to be applied in the science learning process. The argumentation ability of Indonesian students is still low [1], [5]. Whereas a critical aspect of scientific literacy is understanding and applying scientific argumentation skills that encourage students to ask questions and make scientific arguments so that they are effective in improving students' academic abilities. As Agusni's research results, there was an increase in learning outcomes due to the students' argumentative abilities by applying a problem-based learning model [6].



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In the academic world, several important reasons must be known related to the argumentation ability profile. First, it can determine the actions to be applied in the science learning process, namely increasing understanding and attaining the cognitive level. Second, scientific arguments in the science learning process can restore the achievement of science education in a balanced manner, namely: conceptual goals to be able to understand scientific ideas, cognitive goals to improve reasoning abilities, epistemic goals to be able to assess the reasons given and social goals to increase collaboration skills students and motivation to learn [5]. Learning science can be interpreted as a process or act of making a person to learn so that they can produce findings in the form of facts, principles, concepts, laws, theories, and models into a collection of knowledge by the field of study, for example, physics, chemistry, biology, geology and zoology [7].

Chemistry is one of the disciplines that the nation's current generation must pursue the advancement of science in the future. But in fact, Gabel argues that chemistry is an abstract and difficult material to study [8]. Students have difficulty understanding chemical concepts because chemistry has a high abstract value [9]. So, to understand chemical concepts, multiple chemical representations are needed. In order to facilitate the understanding and development of chemical concepts, multiple chemical terms are required, namely linking the macroscopic, submicroscopic and symbolic levels [10]. This can be proven by the effectiveness of using student books based on chemical representations to improve students' understanding of chemical concepts [11], [12]. From this statement, all the subject matter of chemistry requires a concept of representation to make it easier for students to understand the concept of chemistry, including the subject of changes in the form of substances. Changing the form of substances is one of the topics taught to students in Vocational High Schools and higher education. Changes in the form of matter learn about changes in the physical properties of matter. The number of concepts related to macroscopic, submicroscopic and symbolic representations of the material, makes it a challenge for students to be able to understand the material description properly without any misconceptions because changes in the form of substances are a subject whose application is often found in everyday life.

The ability of scientific argumentation is something that is considered important for further study, especially on the subject of changes in the form of substances. Previously, the ability of scientific argumentation has been researched in several chemical concepts such as chemical bonds [13], basic laws of chemistry [14], buffer solutions [5], [15], thermodynamics [16], [17]. The subject matter of changing the form of substances is a phenomenon that is often found in everyday life, especially around the environment of students. In addition, subjects that have types such as changing the form of substances require caution in the teaching process, because in this material students are required to be able to connect the facts obtained in everyday life with concepts or theories learned in the learning process. For this reason, the students' argumentation skills can be a solution to these problems, because the ability of argumentation can act as scientific discourse in connecting students' understanding of the phenomena encountered with the concepts obtained in the learning process to become a complete knowledge, so that can become the nation's children who act as a driver of the nation's competitiveness in the future. For this reason, the purpose of this study is to determine the ability of scientific argumentation of vocational high school students majoring in chemical analysis on the topic of changing the form of substances.

2. Method

This research used qualitative descriptive research. The research studied the ability of scientific argumentation of vocational high school students majoring in chemical analysis on the topic of changes in the form of substances. The population in this study were students of vocational high school 1 Gorontalo, and the sample used in this study were students majoring in chemical analysis with a total sample of 173 students consisting of students of class X, XI and XII. The ability of scientific argumentation is seen based on students' ability to provide evidence of arguments and the ability of students to justify arguments. The students' scientific argumentation ability data were obtained using a four-level multiple-choice test instrument. The first level question (Q1) is used to measure students

'ability to provide evidence of arguments and the third level question (Q3) is used to measure students' ability to justify arguments or reasons for answers at the first level. At the same time, the second (Q2) and fourth level questions (Q4) is used to measure students' confidence in providing evidence and justification so that students' conceptual understanding can also be obtained by using CRI to strengthen the results of students' scientific argumentation skills. The questions used in this study consisted of 5 question indicators distributed in 20 items, as shown in Table 1.

Table 1. Question indicator

Number	Indicator	Question Number
1	Understanding of factual phenomena	1, 6, 11 and 16
2	Understanding of the form of matter	2, 7, 12 and 17
3	The process of changing the form of a substance	3, 8, 13 and 18
4	The relationship between the form of matter and its changes	4, 9, 14 and 19
5	Understanding of submicroscopic changes in the form of substances	5, 10, 15 and 20

Data analysis used in determining students' scientific argumentation skills is through the following stages:

1. Analyze each of the Q1 and Q3 answers. If the answer is correct, the score is 1 and if the answer is wrong, the score is 0
2. Add up the respective scores for Q1 and Q3 obtained by all respondents in one item.
3. Calculating the percentage of ability to provide argument evidence and justification of arguments.
4. Analyze the score of the respondents' argumentative ability by adding up the scores for the evidence of the argument and the justification of the argument.
5. Analyze the score of the respondents' argumentative ability by adding up the scores for the evidence of the argument and the justification of the argument.
6. Calculating the percentage of argumentation ability using equation 1:

$$P = \frac{X}{JS} \quad (1)$$

Where: P = The percentage of students' scientific argumentation skills; X = Total score of scientific argumentation ability; JS = The maximum number of student scores [18].

Data analysis was carried out to measure students' conceptions using the CRI technique. The choices of CRI level used in this study were (1) guessing, (2) very unsure, (3) unsure, (4) sure, and (5) very unsure. The analysis stage begins by determining the criteria for student answers related to the correctness of the answers given in Q1 and Q3, while for CRI in Q2 and Q4 it is determined by (1) if $CRI > 3$ then the confidence level of the answer is high (2) if $CRI \leq 3$ then the level low confidence answer. Furthermore, the answer analysis data are classified according to 5 categories of answers, namely understanding the concept, misconception false positive, misconception false negative, all misconception and not understanding the concept as shown in Table 2 [19], [20].

Table 2. Answer category classification

Category	Combination of Answers			
	Selection (Level I)	First sure level (Level II)	Reason (Level III)	Second sure level (Level IV)
Understand the Concept (UC)	Right	High	Right	High
Misconception False Positive (MFP)	Right	High	Wrong	High
Misconception False Negative (MFN)	Wrong	High	Right	High
All Misconception (AM)	Wrong	High	Wrong	High

Do not Understand (DU)	Right	High	Right	Low
	Right	High	Wrong	Low
	Right	Low	Right	High
	Right	Low	Right	Low
	Right	Low	Wrong	High
	Right	Low	Wrong	Low
	Wrong	High	Right	Low
	Wrong	High	Wrong	Low
	Wrong	Low	Right	High
	Wrong	Low	Right	Low
	Wrong	Low	Wrong	High
	Wrong	Low	Wrong	Low

The results of the classification of the answer categories are used as the basis for calculating the percentage of students' conceptual understanding of the topic of changing the form of substances using equations:

$$\text{Percentage X} = \frac{\sum x}{N} \times 100\% \quad (2)$$

With: X = Category type (UC, MFP, MFN, AM and DU); N = Total number of students

3. Result and Discussion

The ability of students' scientific argumentation was obtained from the results of students' ability to provide evidence of arguments and justification of arguments. The results of students' abilities in providing argumentative evidence were shown in Table 3, and students' abilities in justifying arguments in Table 4.

Table 3. Percentage of proof of argument

Question Indicators	Percentage of Proof of Argument (%)		
	Class X	Class XI	Class XII
Understanding of factual phenomena	23.74	25.46	22.79
Understanding of the form of matter	24.69	26.37	23.86
The process of changing the form of a substance	22.65	20.43	18.90
The relationship between the form of matter and its changes	18.28	17.99	20.78
Understanding of submicroscopic changes in the form of substances	10.64	9.76	13.67

Table 4. Percentage of argument justification

Question Indicators	Percentage of Argument Justification (%)		
	Class X	Class XI	Class XII
Understanding of factual phenomena	22.41	23.84	21.96
Understanding of the form of matter	20.06	21.89	21.48
The process of changing the form of a substance	17.87	13.70	15.01
The relationship between the form of matter and its changes	26.96	27.58	27.65
Understanding of submicroscopic changes in the form of substances	12.70	12.99	13.90

From the results of the percentage of evidence and argument justification, the students' scientific argumentation skills on the topic of changing the form of substances were obtained as in Figure 1.

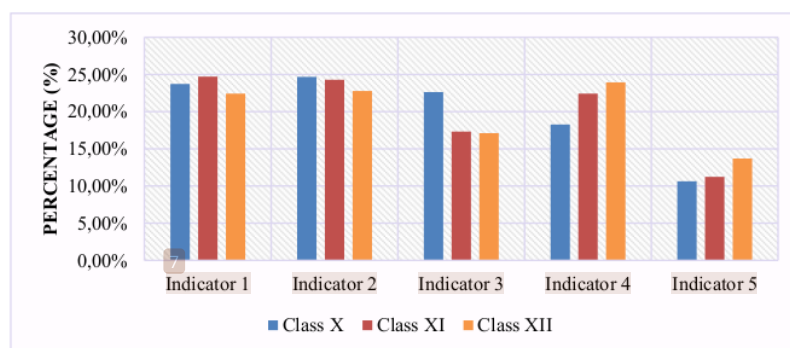


Figure 1. Percentage of argumentation ability

The five indicators on the topic of changes in the form of substances, it was found that students of class X, XI and XII found it easier to provide arguments about factual phenomena (23.12%; 24.71%; 22.41%) and the form of substances (22.54%; 24.30%; 22.77%), while students. It was more difficult to provide arguments, to understand the submicroscopic indicators that were changed in the form of substances as evidenced by the lowest percentage value. Therefore, by these indicators, it was compared to the other four indicators. This can also be seen from the results of students' abilities in providing evidence of arguments and justification arguments. These could be seen from the lowest percentage is found in submicroscopic indicators of change in form. The difficulty of students in providing arguments about the submicroscopic aspects of the topic of changing the form of substances is caused by students' low conceptual understanding of the submicroscopic indicators as shown in Figure 2.

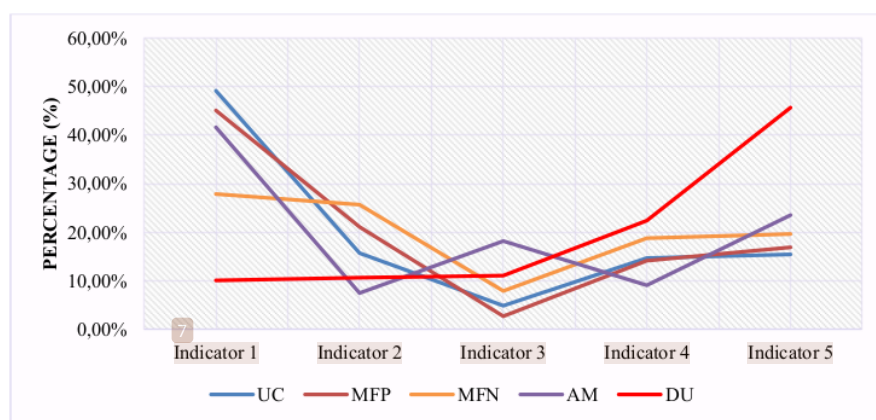


Figure 2. Percentage of student conception

The results of students' conception can be seen from the percentage of students who understand the concept well. Therefore, students who experience misconceptions and students who do not know the concept of changing the form of substances. Of the five indicators, it was found that students understood the concept better on indicators of factual phenomena (49.13%), the form of matter (45.09%) and the relationship between the form of matter and its changes (41.62%). In contrast, students who experienced the worst misconception, namely all misconception, contained on indicators about submicroscopic changes in the form of substances (22.40%), not only misconceptions, but submicroscopic indicators also had the highest percentage in the category not understanding the concept. This proved that students

do not understand the concept well in the submicroscopic part of changes in the form of substances (45.66%). From the results of the students' conception obtained, it supports the data on the ability of scientific argumentation [21], [22], because the percentage of students' scientific argumentation ability on submicroscopic indicators of changes in substance form is very low, this was in line with the number of students who did not understand the concept of submicroscopic changes in substance form properly.

4. Conclusion

It can be concluded that students are still less capable of providing scientific arguments on the topic of changing the form of substances, especially on indicators about the submicroscopic part of changes in the form of substances, this is supported by the student's conception, namely the students' low conceptual understanding of the topic of changing the form of substances.

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