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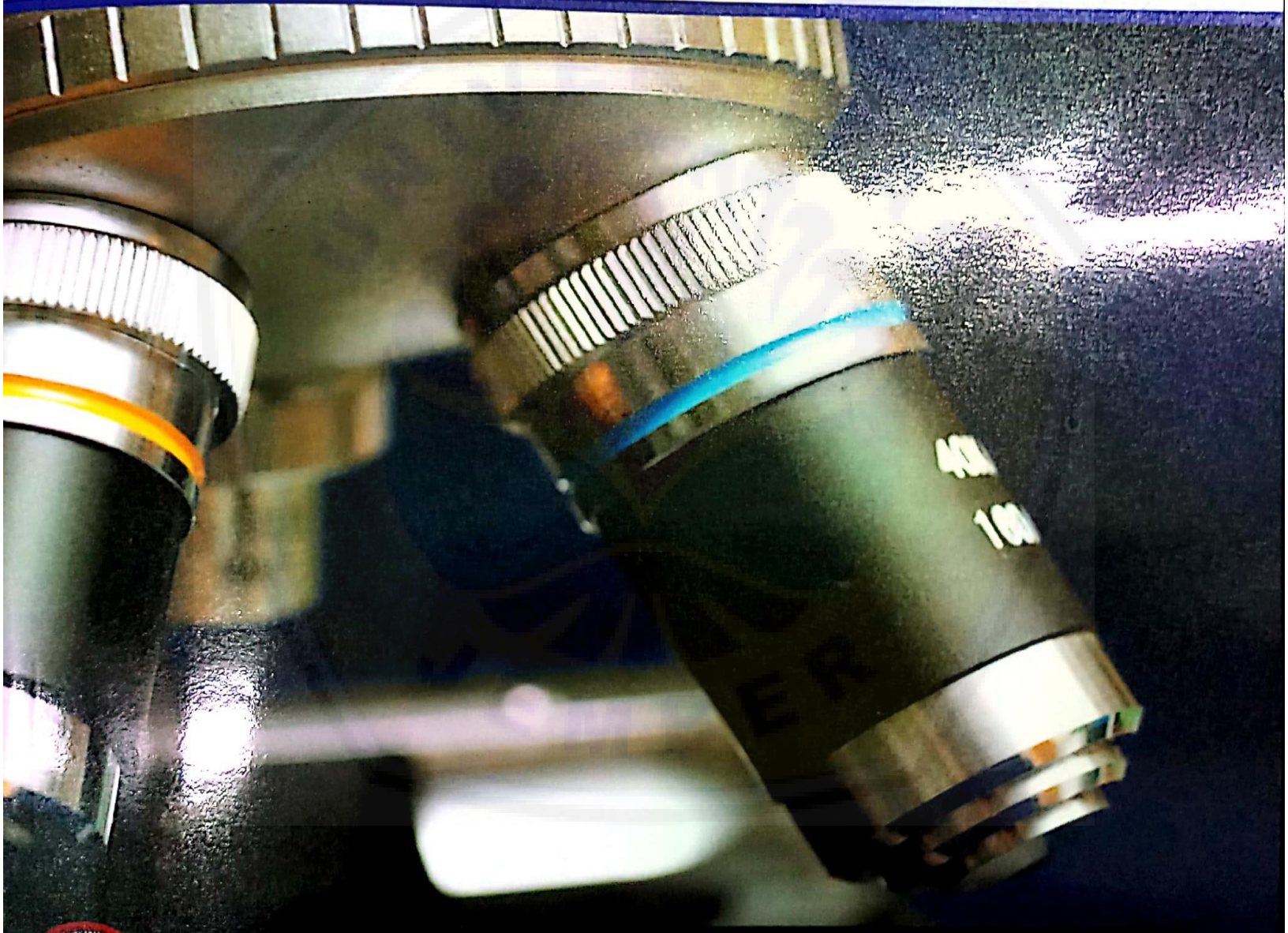

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STUDENTS' ERRORS IN SOLVING SCIENCE REASONING-DOMAIN OF TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY (TIMSS)

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ABSTRACT

This research aims to identify the errors of students' answers in solving the TIMSS cognitive domain of reasoning. This research was a qualitative descriptive research. A total 259 students from four secondary schools located in rural and urban areas in Jember, East Java participated in a paper and pencil test. Error identification was examined by reducing the result of wrong students' answer and grouping based on error type of general errors. The results showed that the average percentage of total errors from the four schools were contradicting error of 7.3%, disregarding evidence error of 5.2%, misreading error of 45.7%, and opinion-based judgment error of 40.9%. In conclusion, there were four types of general errors made by students in answering TIMMS test item of reasoning domain with misreading and disregarding evidence as the highest and lowest error, respectively.

Keywords: students' errors, TIMSS,cognitive domain of reasoning.

INTRODUCTION

The quality of education is often used as a barometer of a country's development. Students' ability to solve math, science, reading and their application in daily life is seen as a good quality illustration of special education for students (Johar, 2012). Indonesia had five times participated in the Trends in International Mathematics and Science Study (TIMSS), an achievement program that measures students' achievement levels in both content and cognitive domains (Akilli, 2015; Anggraini &Wasis, 2014).

Based on the results of TIMSS for last four years, Indonesia lied in the rank of the top five average from below (Akilli, 2015). In its participation, Indonesia only reached Low International Benchmark. The result of TIMSS 2011 in the field of science showed that the high order thinking skills of Indonesian students remain in the low category which is under the international average score. At these levels, Indonesian students were generally judged only to be able to remember scientific facts, terms, laws and to use them in drawing simple conclusions (Anggraini&Wasis, 2014). The average percentage of correct answer of cognitive domains of Indonesian students was low. The correct answers of knowing, applying and reasoning domain of Indonesian students were only 36%, 27%, and 20%, respectively (Anggraini& Wasis, 2014; Mullis et al., 2012).

Those result showsthat reasoning domain was the lowest level for the Indonesian students. It indicates that the capability for analyzing, synthesizing, and generalizing data and concepts of science into the new milieu in their daily life was weak. Those results also denote that the errors

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made by students are terribly high. It might happen due to some conditions, first, teachers mostly train students using C1 and C2 level of cognitive domain (Marlina et al., 2017), and second, the lack of ability of Indonesian students to think critically (Busyairi & Sinaga, 2015). Critical thinking becomes a fundamental skill to overcome not only any problems offered in the test of TIMSS but also the problems in daily life (Gierl, 2007). Students' error is defined as an inappropriate response in answering tasks (Markawi, 2015). Detailed error analysis is needed in order to identify the student errors, possible causative factors and provide the ways addressing the problem as well. Through the error analysis, the weaknesses of students in solving the problems will be obtained clearly. Errors made by students can be used as a consideration to improve teaching and learning activities. Furthermore, it can enhance students' learning outcome

Analysis of students' error is considered as the main source to diagnose difficulties of learning and to access students' reasoning (Batanero et al., 1994; Lim, 2010; Brodie, 2014). Prevost and Lemons (2011) found that the types of errors made by students in the theoretical framework of problem-solving for biological concepts are divided into two types namely general errors and specific errors (table 1) (Prevost & Lemonds, 2016).

Table 1. Students' Errors of Solving Biology Problems

Problem Solving Errors	Description
Domain-general errors	
Contradicting	Stated two ideas that were in opposition to each other
Disregarding Evidence	Did not use some or all of the data provided in the problem
Misreading	Read the question prompt or answer options incorrectly
Opinion-Based Judgment	Gave an opinion and did not use biology content knowledge
Domain Specific errors	
Making Incorrect Assumptions	Stated that the graph or other visual representation provides no useful information
Misunderstanding Content	Showed incorrect understanding of content knowledge.

This study aimed at identifying and clarifying Indonesian students' errors when solving reasoning tasks. Students having intuition while experiencing or solving problems may support science teachers to improve their achievement.

METHODS

The research was conducted in four secondary schools located in a rural and urban area of Jember, the Province of East Java. A total of 259 students from those schools participated in both paper and pencil test. Questionnaire and interview to the science teacher were also used to collect data as the purpose was to provide additional information for analyzing the students' answer. Tenth-reasoning science test items of TIMSS were used as test questions. The objective questions of TIMSS were modified into essay questions by adding the reason for each students' answer.

After the test, the results of the sample were examined to be compared with those Indonesian students participated in the TIMSS surveys. For this purpose, the percentages of correct answers of Indonesian students participated in the TIMSS 2011 survey with those of students in this study for tenth TIMSS tasks were compared. The tasks that were difficult for Indonesian students in the TIMSS 2011 survey were also difficult for the students in this study. After all students' answers were collected, data reduction was determined by examining the student's work and selecting the wrong answer and then grouping the errors based on the general error domains, namely: (1) contradicting; (2) disregarding evidence; (3) misreading; and (4) opinion-based judgment (Prevost & Lemons, 2016). The analyzing and grouping errors' answer used qualitative content analysis (Patton,

1990) and matches the keywords of each general error domain and students' answer. The percentage of each type of error can be determined by using the following formula.

$$P = \frac{n}{N} x\ 100\%$$

Note:
P : Percentage of each error
N : Number of errors for each error
N : Number of errors for all error

The criteria of problem-solving ability based on TIMSS cognitive domain used the criteria as in table 2 (Arikunto, 2009).

Table 2. Percentage Criteria of Problem Solving Capability of Criteria Value

Value	Criteria
0% ≤ P < 20%	Very low
20% ≤ P < 40%	Low
40% ≤ P < 60%	Normal
60% ≤ P < 80%	High
80% ≤ P < 100%	Very high

RESULTS AND DISCUSSION

The results were qualitative data from students' wrong answers which were analyzed and interpreted according to the predetermined criteria.

Table 3. Percentage of Student Error in Answering TIMSS Reasoning Domains

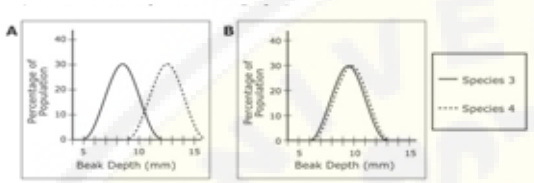
School / Class	Error			
	Ct	DE	Mr	OBJ
School 1				
A	17.3%	5%	35.2%	42.5%
B	5.1%	1.3%	40.5%	53.1
Average	11.2%	3.1%	37.8%	47.8%
School 2				
A	13.6%	13.6%	43.8%	29%
B	8.4%	9.9%	38.4%	43.3%
Average	11%	11.7%	39.6%	36.1%
School 3				
A	1.2%	10.3%	49%	39.5%
B	1.4%	1.7%	35.2%	58.2%
Average	1.3%	6%	42.1%	48.8%
School 4				
A	10.2%	0%	46.5%	43.3%
B	1%	0%	80.6%	18.4%
Average	5.6%	0%	63.5%	30.8%
Average total	7.3%	5.2%	45.7%	40.9%

*Ct=contradicting; DE=disregarding evidence; Mr=misreading. OBJ=opinion based judgement.

Overall, the most common error was misreading of 45.7%, followed by opinion based judgment, while disregarding evidence was the leest errors (table 2). The details of each error made by students are explained below.

Misreading Error

The most frequent errors that the students did were misreading (table 3). For instance, students were asked to answer the following question: *"Two other species (species 3 and 4 species) live on the Santa Maria Island, which also has a range of seed types. Which of the following graphs shows a range of break depths for species 3 and species 4 that would best ensure the survival of both species on the Santa Maria island?"*



Explain why this range of the beak depths is best."

Student's answer was "A. because the above chart shows the number of bird populations". The Answer is the correct choice but the reason was false. The question requires the students to compare which graph is better to survive, while the students' answers have no relation to the question. It just repeated the information on the problem. It was possible because the students read in a hurry so they did not completely understand the main key to the question. This error belongs to misreading that was caused by quick answering the question while reading it. Students tended to be less thorough in reading resulting in choosing the wrong answers. In addition, students tended to ignore the problem and may choose not to answer it. The errors that were often done by the students in solving the problem are translation errors, i.e. errors in changing information. Students are having difficulty in digesting or understanding the language, and interpreting words or symbols (Arslan et al., 2012).

Many students ignored some questions so that some questions were left without answers. According to the results of the interviews with teachers, students' motivation was low and students tended to get bored with memorizing materials. Moreover, students did not pay attention to questions and they answered many questions without reading and understanding the materials first. Students tend to be less prepared and cheat on daily tests.

Opinion-based Judgment Error

Opinion-based judgment errors are errors that express opinions without applying biological knowledge content. Students have an opinion in answering questions based on their feelings that the answers seem to be true. This relates to the limitations of factual knowledge with marked misconceptions errors. A misconception is a part of the wrong concept framework but it is considered as correct by the students so that there are consistent and repeated errors (Natalia&Subanji, 2016). It is needed to understand the basic concepts that will facilitate subsequent concepts. A low understanding of a concept makes students make their own sense of the concept (Suparno, 1998). Misconceptions have been recognized as the main factor affecting students' understanding of science in secondary level school (Coll & Treagust, 2003), even teachers have certain misconceptions as well (Burgoon et al., 2011).

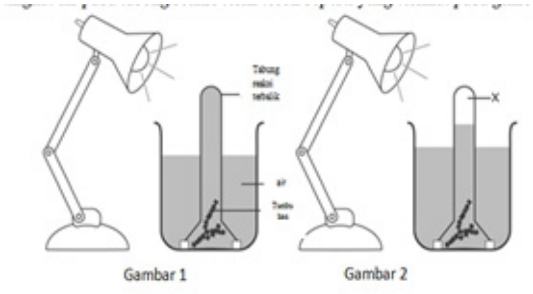
The opinion-based judgment error in this study could be found on this question: *"Explain why your heart beats faster when you exercise."*

Students' answer was "If we do many movements, then our heart will rate faster caused by active organs". The answer shows that the opinion or the corresponding answer seemed to be true without linking to the known biological concepts about how much oxygen required when exercising, resulting in faster heart pump to meet the needs of oxygen in the body.

Contradiction Error

The mistake of contradiction relates to the error by stating two different ideas that conflicting to each other. Some students make choices and reasons for their answers in accordance with what is ordered on the question but ultimately the reasoning is contrary to the choices given in the answer. This can happen because of misconceptions experienced by students. A misconception is an inaccurate notion of the concept, the classification of false examples, the confusion of different concepts and the hierarchical relationships of concepts that are not correct[16]. Thus, misconceptions lead students developed erroneously and different from scientifically accepted concept (Kose, 2008; Yasri, 2014).

In this study, contradiction error could be found in this question: *"The picture shows how a student set up some apparatus in a laboratory for an investigation. The inverted test tube was completely filled with water at the beginning of the investigation as shown in Figure 1. After several hours, the water level of the test tube had gone as shown in Figure 2."*



What is the content of the top part of the test tube labeled X in Figure. 2?

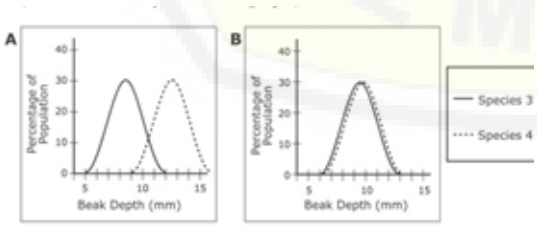
- *air*
- *oxigen*
- *carbon dioxide*
- *vacuum*

Explain your answer."

Students' answer was "Oxygen, because the water is made for photosynthesis, and because there is a light", which is correct. Plants produce oxygen at the time of photosynthesis, but in the next statement "yes because the water is made for photosynthesis and because there is a light" this reason is not related to the first statement given by students about photosynthesis.

Disregarding Evidence Error

The rare error made was disregarding evidence. It occurs when the students fail to demonstrate the use of evidence in some of the problems including the data in question or in visual representation. Whereas this data can be used later to help the students choose the best option but many students do not give an indication that they are considering the data (Suparno, 1998). *"Two other species (species 3 and 4 species) live on the Santa Maria island. which also has a range of seed types. Which of the following graphs shows a range of break depths for species 3 and species 4 that would best ensure the survival of both species on the Santa Maria island?"*



Explain why this range of the beak depths is best."

Student's answer was "B. because the size of the beak is equal to the population". It seems that students ignored the other graphs and considered only one graph so they chose the wrong one. However, by choosing the wrong graphs, students were able to find out new information about finch birds' ability to survive considering the number of different foods and the size of beaks.

This error occurs when students do not use some or all available data. For example, by using only one diagram given to the problem as a comparison. The students tended to ignore some of the data and only focused on the data he or she saw, resulting in the wrong answer. Drawn from the teachers' interview, problems or quetions using comparison chart or diagram were rare.

Overall, the result showed that misreading error was the highest. This result is in accordance with Djarod et al., (2015) and Rahmat (2017). Their research of students' error in answering Physic questions indicated that the misreading was the usual error. Students are under stress when they are reading exam questions due to time monitoring and answer managing. Thus, they are more easily distracted by irrelevant ideas and less capacity available to focus on the task. This condition will lead to misreading and misinterpretations more likely (Kiwan et al., 2000).

CONCLUSION

In sum, the most common error made by students was misreading errors due to carelessness in reading, which affected the students in selecting the wrong answer. While the rarest error type performed by students was disregarding evidence error; it was because students did not use some or all of the data available in the problem. This study also revealed that identifying students' error is crucial as the initial step to overcome students' difficulties and to improve teaching and learning in science.

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