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Development and Application of a Three-tier Test Diagnostic Instrument to Assess Junior High School Students' Misconceptions in Algebra

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***Abstract*—This paper describes the development and the use of a three-tier diagnostic instrument to identify the misconception of the students in algebra. The three-tier diagnostic test was developed using the theoretical framework by Treagust. The first tier assessed content knowledge; in the second tier, a reason is selected for the content answer; and the third tier allowed students to select how confident they were in their answers for the first two tiers. The final instrument consisted of 10 items. The development from junior high schools grades 7 which have accreditation grade A, B, and C in South Sulawesi. The three-tier test diagnostic instrument used in this study had been assessed in terms of being valid and reliable. The diagnostic test on 167 students from four schools showed that the category to understand the material of 20.4%; amounting to 53.5% misconceptions category and the category did not understand the material of 26.1%. It has been typically identified from the study that student errors and misconceptions pertaining to the following main areas in algebra: Students lacked the relevant understanding of the definition of the degree of variable, variable, coefficients, and constants; Apart from that, students are likely to have misconceptions in solving equations correctly. Furthermore, students lack an understanding of changing problems into mathematical models. The most fundamental misconception surrounding the concept of inequality of students is the lack of knowledge in translating words such as "at least" or "not more than" into mathematical symbols using inequalities.**

Keywords—Algebra, Three-tier Test, misconceptions

I. INTRODUCTION

Misconceptions are particularly important for teachers to know about, as misconceptions can impede learning. As Carlsen [1] states that teachers should know common student misconceptions for the topics that they teach. As it can help them plan lessons for children to overcome their misconceptions [2]. Before misconceptions can be corrected, they need to be identified. Methods that used to determine students' misconceptions include open-and-paper tests (open-ended or multiple-choice items) and interviews. Furthermore, Treagust [3] recommended the use of two-tier multiple-choice instruments as an appropriate alternative to individual open-response questions or interviews as a means of obtaining information about the reasoning of groups of students. The first tier of a two-tier item consists of a multiple choice question, with four choices. The second tier requires students to choose from four reasons to justify or explain their answer to the first-tier question. The design of the options in the second tier is based on research findings, or on students' answers to free-response test items.

In addition to the two-tier test, another type of test has been developed, the three-tier test which is the development of the two-tier test. Kutluay [4] revealed that the three-tier test is a diagnostic test with three levels. This test is the development of two-tier tests combined with a certain response index (CRI) or student confidence level. The first level is related to questions about a topic. The second level asks the reason for the answer at the first level while the third level is about the level of student confidence in answering questions at the first and second levels.

The three-tier instrument described in this paper is an approach to assessing students' misconceptions in algebra. In addition, the data generated from this three-tier instrument allow to identified students' common errors or partial understanding in algebra?

II. DEVELOPMENT OF THE THREE-TIER TEST

The design of three-tier items used in this research has been based on findings of students' common alternative conceptions or the errors and difficulties they commonly encounter in algebra topic. The first tiers of all problems were presented as a scenario followed by a statement to which students responded to a multiple choice question. The second-tier responses of each item that requires students to choose from four reasons to justify or explain their answer to the first-tier question and the third tier are about the level of student confidence in answering question1s at the first and second tier. As the final instrument was intended to assess junior high school students' misconceptions in algebra. This instrument was developed using the theoretical framework by Treagust [3] with three stages: defining the content, obtaining information about students' conception, and developing a diagnostic instrument.

III. RESULT

A. *Students' performance on the 10 three-tier test*

Based on the results of the three-tier test trial, the category to understand the material of 20.4%; amounting to 53.5% misconceptions category and the category did not understand the material of 26.1% that can be seen in Figure 1.

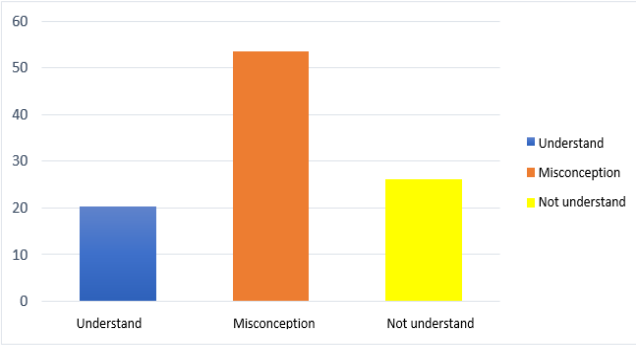

Fig. 1. Percentage of Students' Answered of the Three-tier Test on Students' Understanding and Misconceptions

B. *Students' Performance for Each Item of the Three-tier Test*

There are four categories related to the students' understanding which are analyzed from 10 items. Misconception consists of two categories: false positive and false negative; understand, and not understand. The distribution of the percentage of categories per item can be seen in Figure 2.

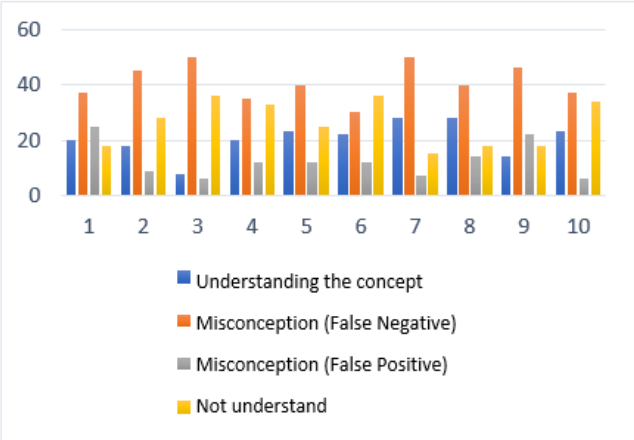

Fig. 2. Percentage of Students' Understanding, False Positive, and False Negative for Each Item of the Three-tier Test

False positives occur if the answer at the first tier is correct, but at the second tier is wrong and is supported by confidence in both answers. The highest percentage occurs in problem number 1 almost 25% of students, which suggests that many students experience misconceptions related to the definition of variable degrees. In addition, false negative occurs if the first tier is wrong and the second tier is true or the first and second tier are wrong and are supported with confidence in the answer. On average, false negative occurs in each item with a high percentage. This means that students experience difficulties in solving linear equations and linear inequalities of one variable. In addition, students experience difficulties in changing everyday problems related to linear equations and linear inequality of one variable into mathematical models.

For Items 7 and 8, 28% of the students gave the most accurate responses. This item required students to change everyday problems related to linear equations and inequalities in one variable to the form of a mathematical model indicates that a high level of conceptual understanding occurred compared to other items. In contrast, the response patterns for items 3 and 6 with a very poor level of understanding with the presentation about 36%, suggest that knowledge of the concept of variables, coefficients, and constants is very lacking. In addition, the level of student understanding in solving linear inequality in a fractional form variable is still very lacking while the level of understanding of the concept was less average experienced by students in almost all items.

In particular, the answers of students from the three-tier test show that students have many misconceptions in algebra topic. Basically, students have problems with understanding the definition of variables, coefficient, the degree of variable and constants. Apart from that, the student has some misconceptions in solving equations and inequality as well. Furthermore, the findings showed that the instrument was useful for identifying problem types in which students have a misconception as the following:

1) Determining the degrees of variable

Topics in problem number 1 discuss variable degrees. Students experience misconceptions related to the definition of variable degrees. Basically, some students seem to have problems with understanding the concept of the degree of the variable.

2) Determining Variables, Coefficients, and Constants

Gaining an accurate understanding of variables is one challenge many students face when learning algebra. The percentage of misconceptions (false negative) 25% explained that misconceptions occur due to the lack of understanding information obtained by students related to definitions of variables, coefficients, and constants. On average students do not yet know how to distinguish between variables, coefficients, and constants. This was also supported during the test; some students questioned the definition of variables, coefficients, and constants.

Therefore, students' prior experiences of using symbols in arithmetic would impact on their understanding of the meaning associated with formal symbols in algebra. As Skemp [5] stressed that "A variable is, in fact, a key concept in algebra."

3) Determining variables, coefficients, and constants as well as examples and not examples of linear equations of one variable

Students experience false negative in this problem indicates that students do not know in identifying variables, coefficients, constants and include examples or not one variable linear equation. Moreover, student answers further indicate that there were some basic problems with distinguishing between variables, expressions, and equations.

4) Determining the value of x from the linear equation of one variable

The percentage of false negative and does not understand the concept is almost the same. He applied the algorithm without referring to the meaning of it. Lack of monitoring of the solving process was another mistake because he applied the same method to both linear equations. In the end, when he was even stuck with the solution, he was unaware that he had chosen the wrong method.

5) Determining the set of linear inequalities in one variable

The misconceptions experienced by students related to the lack of understanding of the "inequality" sign so that many students cannot solve properly. He mistakenly applied a method for solving inequality equations to solve the linear system. In addition, students' experience false negative. This is because students lack understanding in changing into mathematical models. The most fundamental problem of students is the lack of knowledge in the use of signs interpreted with the word "no more." Students interpret it as well as the word "less than" even though it has a different meaning in terms of the use of signs. Also, students seemed to have a poor understanding of manipulating algebraic expressions.

6) Changing everyday problems relates linear equations and linear inequality to one variable to a mathematical model

Students experience a false negative have difficulty translating a word problem into mathematical models. Lack of understanding of students in translating due to lack of practice. Some students explained that during the learning process students are not given examples of everyday problems. Moreover, students mistakenly applied a method for solving quadratic equations and inequality to solve the linear system. In fact, understanding of algebraic relations is an important component of algebraic competency [6].

IV. Conclusion

The three-tier test has been developed which can be used as an instrument in identifying misconceptions in the linear material of one variable's linear inequality and inequality by using the revised Treagust development model. The final instrument consisted of 10 items. The development from secondary schools grades 7 which have accreditation grade A, B, and C in South Sulawesi. The three-tier test diagnostic instrument used in this study had been assessed in terms of being valid and reliable. Based on the results of the three-tier test that was tested on 167 students from four schools showed that students are experiencing misconceptions with a percentage of 53.5%, understanding the concept of 20.4%, and did not understand the material of 26.1%.

References

[1] Carlsen, *Domains of Teacher Knowledge, in Examining Pedagogical Content Knowledge: The Construct and Its Implications for Science Education*. ed. Boston: Kluwer Academic, 1999.

[2] M. Kambouri-Danos, "Children's misconceptions and the teaching of early years' science: a case study," *J. Emergent Sci.*, vol. 7, 2014.

[3] D. F. Treagust, "Diagnostic assessment of students' science knowledge," in *In S. M. Glynn & R. Duit (Eds.), Learning science in the schools: Research reforming practice*, 1995, pp. 327–346.

[4] Y. Kutluay, "Diagnostics of eleventh grade students' misconceptions about geometric optic by a three tier test," Middle East Technical University.

[5] R. R. Skemp, *The psychology of learning mathematics*. Hillsdale, NJ: Lawrence Erlbaum, 1987.

[6] R. Oldenburg, "Structure of algebraic proficiency. In J. C. Sung (Ed.)," in *Proceedings of the 12th International Congress on Mathematical Education (ICME-12)*, 2012, pp. 2138–2145.