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Development of Contextual Teaching and Learning (CTL) based Teaching Materials to Train Students' Representation Ability

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ABSTRACT

The purpose of this research is to produce teaching materials based on Contextual Teaching and learning (CTL) to train students' representational skills that are valid, practical, effective and to train students' representation skills at SMA Negeri 3 Martapura. The subjects of this study were students of class XI MIA 1 which amounted to 30 students. The method used in this research is the Plomp model development research which consists of three phases, namely preliminary research, prototype making phase (prototyping), and assessment phase (assessment phase). Data analysis techniques consist of analysis of the validity of teaching materials, analysis of practicality of teaching materials, analysis of the effectiveness of teaching materials and analysis of students' representational abilities. The data from the four analyzes were analyzed descriptively qualitatively by telling what was found during the research process. Data collection techniques used are walkthrough, questionnaire and post-test. From the results of research conducted by researchers stated that the teaching materials developed were included in the very valid category with a presentation of 86.6%, the effective category with an average value of 83.92, the practical category with a presentation of 83.42% and the results The post-test of students' representation abilities of class XI MIA 1 is very complete with an average of 89.8%.

Keywords: Representation; Contextual Teaching and learning (CTL).

1. INTRODUCTION

The National Council of Teachers of Mathematics [1] suggests that there are five standard competencies for learning mathematics, including: (1) Problem Solving, (2) Reasoning and Proof, (3) Connections, (4) Communication; and (5) Representation. This shows that one of the five standard competencies of mathematics learning that students must possess is the ability to represent. Representational ability is the core of mathematics learning where students can develop and deepen understanding of concepts and relationship between mathematical concepts using various kinds of representations [1].

The ability of representation is a very important aspect in learning mathematics because representation can be a bridge that connects abstract mathematical concepts with real-life contexts in everyday life so that it can help students understand concepts, help build other representations that are more concrete and can be used for reasoning to find answer [2][3]. Representation

helps students to communicate mathematical ideas and ideas of students in solving a problem through objects, pictures, words, or mathematical symbols [4][5]. In addition, the representation ability used by students in problem solving shows the level of understanding of students' concepts of a material. The use of the correct representation will help students to simplify and solve a problem more effectively [6].

But in reality, the representation ability of students in Indonesia is still very low. This can be seen in the results of the 2015 TIMSS mathematics study where Indonesia is ranked 44th out of 49 countries and only 20% of Indonesian students are able to achieve the Intermediate International Benchmark level from the international average of 75%. At this level, students are faced with questions with indicators of being able to apply basic mathematical knowledge in simple situations, able to connect and draw flat shapes, and be able to read and interpret tables and graphs [7]. Meanwhile, the 2018 PISA math results found that

Indonesia was ranked 72 out of 78 countries. From the OECD average of 76%, Indonesia is far behind where only about 28% of students are able to reach level 2 with indicators of students being able to interpret and recognize, without direct instruction, how a situation or situation can be represented mathematically [8].

The low representation ability of students is due to a lack of understanding and difficulty in translating questions, especially story problems so that students find it difficult to represent real world problems into representative mathematical problems [9][10]. In addition, learning mathematics does not provide opportunities for students to develop their own representations. Students only follow the representation of the sample questions that have been given directly by the teacher without discussion or exploration activities [11][12]. Therefore, a more varied mathematics learning is needed using media and learning approaches to familiarize students with expressing their mathematical ideas in various kinds of representations.

One effort that can be done is to use learning media such as quality teaching materials so that they can help students improve understanding, present data in an interesting and reliable way, facilitate data interpretation and condense information [13][14]. But unfortunately the majority of teachers are less trained in developing their own teaching materials and prefer to use available teaching materials [15]. While the teacher's ability to compile or design material in a teaching material is one of the most important things in determining the success of the teaching and learning process [16][17]. Therefore, [18] hopes that teachers in schools can continue to practice to be able to develop diverse and interesting teaching materials by applying meaningful learning principles such as starting learning from the concrete to understanding abstract concepts, especially matrix.

Learning mathematics should begin with the introduction of problems that are appropriate to the contextual situation or problem. By presenting contextual problems in learning mathematics, students can master mathematical concepts [19][20]. An approach that can be used as an alternative for the teaching and learning process to improve the representation ability of high school students compared to conventional learning is the Contextual Teaching and Learning (CTL) Approach [21]. This is because the CTL approach is learning that helps teachers relate the material to be taught to students' real world situations and encourages students to make connections between their knowledge and its application in their daily lives [22][23]. In addition, CTL helps students in finding concepts, constructing ideas, being active and able to communicate well during the learning process.

From several previous studies, it was found that CTL was able to effectively improve students' representational abilities compared to conventional learning [24][25]. In line with this, it was found that CTL-based teaching materials containing mathematical representation questions were able to make students interested in discovering the mathematical concepts being studied and were also able to effectively facilitate students' mathematical representation abilities because problems were built from knowledge reconstructed by students. students themselves through the knowledge they have and students develop their ideas according to their perceptions [26]. Teaching materials with this CTL approach also make it easier for students to understand and solve problems in abstract mathematical concepts, one of which is matrix material [27]. Unfortunately, this research is mostly in the realm of research on the application and analysis of CTL for students' representational abilities. Meanwhile, the development of CTL-based teaching materials to train students' representational skills, especially in matrix material, is still very difficult to find.

The development of CTL-based teaching materials is expected to be able to provide alternative learning media that can be used by teachers to train students' representational abilities because CTL presents contextual problems that make students get a meaningful learning experience. In the learning process, students will be trained to find their own mathematical concepts through discussion and exploration of contextual problems.

Based on the description above, researchers are interested in developing teaching materials, especially Student Worksheet that are valid and practical through a research entitled, "Development of Contextual Teaching and Learning (CTL) Based Teaching Materials to Train Students' Representation Ability".

2. RESEARCH METHOD

2.1. Research Procedure

At this stage, the MRF subject has met the Perception of generality indicator, which can already identify a rule or pattern. Besides that students know that the problem presented can be solved by a rule or pattern. This is in line with research that states that students still make mistakes in implementing the planned procedures so that they still experience errors in doing calculations [16].

2.2. Subject

The subjects of this study were 30 students of class XI MIA1 at SMA Negeri 3 Martapura, East OKU Regency, South Sumatra Province.

2.3. Instrument

The research instrument used is the Student Worksheet validation sheet, student response questionnaires, learning outcomes test questions (questions for Student Worksheet descriptions that have been validated by the validator), and post-tests. The Student Worksheet validation sheet is used to measure the validity of teaching materials. Student response questionnaires were used to measure the practicality of teaching materials in terms of material and language interest aspects. The learning outcome test was used to measure the effectiveness of the Student Worksheet and the post test results were used to measure the student's representational ability.

2.4. Data Analysis

Data analysis techniques consist of analysis of the validity of teaching materials, analysis of practicality of teaching materials, analysis of the effectiveness of teaching materials and analysis of students' representational abilities. The data from the four analyzes were analyzed descriptively qualitatively by telling the things that were found during the research process.

3. RESULTS AND DISCUSSION

3.1. Result

The purpose of this study is to produce valid, practical, and effective CTL-based teaching materials and aims to train the representation skills of students at SMAN 3 Martapura. This research uses development research. This development research uses the Plomp model [28] which consists of three stages, namely the preliminary research stage, the prototype stage (prototyping), and the assessment phase (assessment phase).

3.1.1 Preliminary Research

At the preliminary research stage, the first step taken by the researcher was to analyze the curriculum used by SMA N 3 Martapura. Based on the results of observations, the school uses the 2013 curriculum and the KD used by researchers are 3.4 and 4.4. the second step is to analyze the material, the material used by the researcher is the determinant material and the inverse matrix. The third step is the analysis of students, at this stage meeting the mathematics teacher of SMA Negeri 3 Martapura, Dra. Sri Sumarsih, to determine the characteristics of students in class XI MIA 1 as the object of research. Based on the results of interviews, it was found that the number of participants in class XI MIA 1 was 30 people.

3.1.2 Prototyping Stage

At the prototype stage, it consists of two stages, namely realization and validation. At the realization stage, the researcher makes the Student Worksheet design and arranges the components in the Student Worksheet in the form of basic competencies, indicators, learning objectives, Student Worksheet instructions, material summaries, student activities, and questions. At the validation stage, the researcher made two Student Worksheet, namely Student Worksheet meeting 1 for the determinants of the matrix while Student Worksheet 2 for the inverse matrix material. The researcher validates the results of the Student Worksheet design to two expert validators who are UNSRI mathematics education lecturers, namely Zuli Nuraeni, S.Pd, M.Pd. and Novika Sukamningthias, S.Pd., M.Pd., as well as the practitioner validator, namely the Mathematics teacher of SMA Negeri 3 Martapura, Dra. Sri Sumarsih. The things that are validated are in the form of content, constructs, and language in the Student Worksheet. Here is the Student Worksheet that has been validated by the validator.

3.1.3 Assessment Phase

Field test activities on 23 – 24 November 2020 online through a zoom meeting. Consisting of two meetings, the first meeting discussed Student Worksheet 1 on November 23, 2020 and the second meeting discussed Student Worksheet 2 on November 24, 2020. This trial consisted of 30 students of class XI IPA 1 SMA Negeri 3 Martapura who were divided into 6 groups consisting of 5 people in each group.

During the trial process, the learning process was carried out in group discussions on mathematical problem about understanding the material of determinants and inverse matrices. After the discussion is over, before concluding the learning process, the teacher gives assignments to the whole group to do exercise on the Student Worksheet. The results of each group's answers will be assessed and analyzed to determine the effectiveness of the Student Worksheet.

The problem in Figure 1 is an exercise on the determinant of a matrix of the order of 2x2. Figure 2 shows students' answers. Figure 2 is the answer from group 1. The red line in Figure 4.2 indicates that group 1 wrote incorrectly. It should have written the price of one sack of duku and one sack of papaya. The strategy of group 1 in answering the questions in the first step is correct, that is, suppose the price of 1 sack of duku with variable x and the price of one sack of papaya with variable y. The next strategy taken by group 1 is to make a linear system equation of two variables:

Equations: $11x + 9y = 90000$

$$10x + 8y = 820000$$

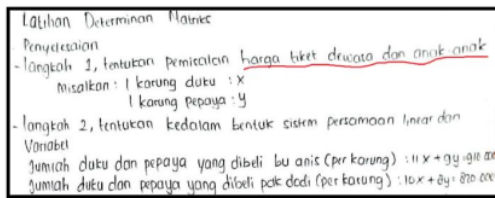**Figure 1** Practice question number 1 Student Worksheet.

Figure 2 Students' answers to practice question number 1 Student Worksheet.

Based on Figure 2, group 1 was able to make a linear equation of two variables correctly. Likewise with group answers 2,3,4,5 and 6 they were able to answer correctly.

3.1.3.1 Ability to represent equations or mathematical expressions

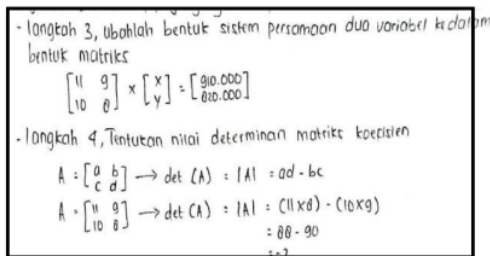Students' mathematical abilities or expressions can be seen from the students' answers below.

Figure 3 Answers to practice questions number 1 Student Worksheet.

Figure 3 is a continuation of the answers from group 1. After group 1 makes a linear equation of two variables correctly. The next step is to convert the linear equation of the two variables into a matrix form. Based

on the answers in Figure 1, group 1 was able to convert the equation into a matrix form properly and correctly. The next strategy is that they find the value of the determinant of the matrix. Before looking for the value of the determinant of a matrix, they must first understand what is the determinant of a matrix and what is the formula for the determinant of a matrix. Based on Figure 4.3, group 1 has found the value of the determinant of the matrix correctly. As for groups 2,3,4,5 and 6 they also answered correctly. The next step is to find the values of x and y using Crammer's rule. Figure 4.4 below is a continuation of group 1's answers using the Crammer's rule.
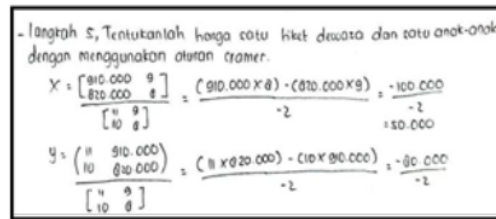

Figure 4 Answers to practice questions number 1 Student Worksheet.

In Figure 4 group 1 has answered with the correct answer because it can find the values of x and y by using Crammer's rule. If they do not know the concept of Crammer's rule, it will be difficult to find the values of x and y. As for groups 2,3,4,5, and 6 they also answered well and correctly.

3.1 3.2 Ability to represent words or written text

The ability to represent words or written text can be seen from the students' answers in Figure 5.
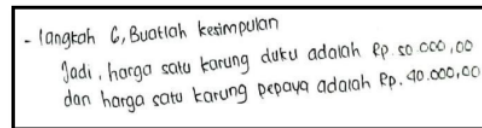

Figure 5 Students' answers to practice questions number 1 Student Worksheet 1.

After students get the value of x and y, group 1 concludes the answer. From the conclusions written, the answers of group 1 are correct. Likewise for groups 2, 3, and 4. However, there were two groups that did not write conclusions, namely groups 5 and 6.

Figure 6 shows exercise 2 which contains Student Worksheet 1.

Figure 6 practice question number 2 Student Worksheet.

3.1.3.3 Visual Representation Ability

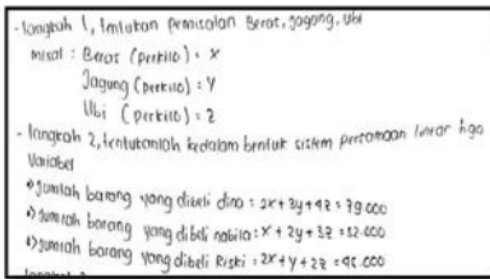The visual representation ability of students can be seen in the following answers.

Figure 7 Student answers to practice question number 2 Student Worksheet.

In Figure 7, each group has been able to answer with the correct answer where students can read the table properly and correctly. From the table, students assume that rice is the variable x, corn is the variable y, and sweet potatoes are the variable z. then from the data in the table students make linear equations of 3 variables to make it easier to answer questions.

Table 1 shows scores for each group.

Table 1. Score of each group

Group	Average Score	Category
1	85.5	High
2	86	High
3	84.5	High
4	85.5	High
5	81.5	High
6	80.5	High
Average	83.92	High

In the data table above, the average value of students is 83.92 so it can be concluded that Student Worksheet 1 and 2 are effective.

After students work on Student Worksheet 1 and Student Worksheet 2, then students are given a response questionnaire consisting of 18 questions. Students are asked to fill out a questionnaire which aims to determine the practicality of teaching materials. The student's questionnaire is in the form of a pdf file which is distributed by the researcher via Whatsapp Group, the student prints the questionnaire file then fills in the questionnaire then the answer results are photographed and sent in pdf form. Below is a table of student questionnaire results. From the results of the student questionnaire data obtained an average of 83.42%, so it can be interpreted that the Student Worksheet 1 and 2 being tested are Student Worksheet that meet the practicality criteria.

After the students filled out the questionnaire, the next step taken by the researcher was to give the post test questions. The purpose of the post test is to see the representation ability of students at SMA Negeri 3 Martapura. The questions consist of four questions and are done by students of class XI which consists of 30 students individually. Based on the results of the post test of 30 students in the class, there were 3 students who got the lowest score, namely 70. While 27 students got a score above 80. The average grade of completeness in the class was 89.8%. So it can be concluded that the representation ability of students after carrying out the trial succeeded.

The validity of the worksheet developed in this study can be seen from the results of the expert validators and practitioner validators, where the average value of the validation results is 86.607% so that it is categorized as valid. In addition, the validity can also be seen from the content, construct, and language criteria where the worksheet have been accepted by the validator although with some suggestions of minor improvements that must be made. In terms of content, the activities in the worksheet that were developed were in accordance with the principles of CTL and the basic competencies of determinants and inverse matrices. In terms of constructs, the developed worksheet is in accordance with the level of ability of class XI students and indicators of student representation ability. Meanwhile, in terms of language, the developed worksheet has used a language that is in accordance with EYD and can be understood by students.

The effectiveness of the developed worksheet can be seen from the results of the analysis of the worksheet trials on students. From the test results of the worksheet it was found that the average value of students was 83.92 so it could be concluded that the worksheet was effective in training students' representation skills. In addition, this effectiveness can be seen from the analysis

of the results of students' answers where students are able to solve questions in the worksheet with indicators of representational abilities that are fulfilled, including visual representation abilities, mathematical expression or equation representation abilities, and word representation or written text abilities.

The practicality of the worksheets developed in this study can be seen from the results of student questionnaires where the average value obtained is 83.42% so that it is categorized as practical. In addition, the practicality of this worksheet is seen during the learning process where the questions in the worksheet with the context of the questions recognized by the students can be understood by students and can be applied in learning. Students can use the information contained in the tables and questions to solve problems in the worksheet. Students are also more enthusiastic and interested in learning mathematics, especially determinants and inverse matrices through attractive worksheet displays and problems related to everyday life.

In addition to producing valid, practical, and effective CTL-based worksheet, this study also tested the post-test to see the representational abilities of class XI students at SMA Negeri 3 Martapura. From the results of the post-test, it was found that the representation ability of class XI students at SMA Negeri 3 Martapura was very thorough with an average score of 89.8%. The results of this post-test show that the CTL-based worksheets that have been developed can be used to train the representation skills of class XI students on determinants and inverse matrices at SMAN 3 Martapura, in line with several previous studies that CTL can improve students' representational abilities [29][30]. This is because and in the concept discovery process in the learning process using CTL-based worksheets, the problems are reconstructed by the students themselves through the knowledge they have and develop their ideas according to their perceptions, as well as mathematical representation questions with contexts known to the students. interested in finding the mathematical concepts being studied so that the learning carried out becomes more meaningful [26]. Meanwhile, from the post-test results, only 3 out of 30 students had moderate representational abilities with a score of 75. This could be caused by students who were not familiar with story questions so they were confused in understanding the questions given and students were only fixated on the story questions. one concept of working on matrix problems [31]. In the post-test results for the NU subject, there are four post-test questions. of the four questions, all the answers to the NU subject are correct. Based on the results of the analysis of answers to NU subjects, the representation ability that often appears is the ability to represent the ability to represent equations or mathematical expressions. The ability to represent equations or mathematical expressions is that

students are able to solve problems by making mathematical expressions [32]. The symbol is used by student help and make it easier to answer questions, in line with research [33]. which says that students do use symbols more because they are used to being made that way.

Word representation or written text is that students are able to answer questions using written text or words [32][34]. Most of students' answers accompanied by conclusions, as well as the explanations using words. This is something that must appear in the word representation [33].

The last is representation ability that appears in the answer to the subject to present information or data from the results of the representation to a diagram, table, or graph representation [35]. In answering questions, students are able to collect information from table analysis and convert it into the form of x, y and z examples, hen create a three-variable linear equation and convert it into a 3-variable matrix form. Students can make this by combining the ability of visual representation and symbolic representation [33].

4. CONCLUSION

Based on the research results, the average value of the Student Worksheet validation results is 86.607% so that it is categorized as valid. The effectiveness of the developed Student Worksheet can be seen from the results of the analysis of Student Worksheet 1 and 2 trials on students. From the test results of Student Worksheet 1 and 2, it was found that the average value of students was 83.92 so it could be concluded that Student Worksheet 1 and 2 were effective in training students' representation skills. The practicality of the worksheets developed in this study can be seen from the results of student questionnaires where the average value obtained is 83.42% so that it is categorized as practical. From the post-test results, it was found that the representation ability of class XI students at SMA Negeri 3 Martapura was very thorough with an average score of 89.8%.

AUTHORS' CONTRIBUTIONS

All authors have contributed significantly in the research and article writing processes.

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