Development of Teaching Materials by Implementing Problem Based Learning-Oriented Virtual Manipulatives to Improve Thinking Ability Critical And Mathematics Problem Solving Class VIII Students of Mars Private Junior High School

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Abstract. This study aims to describe: 1) the validity, practicality and effectiveness of teaching materials developed by implementing virtual manipulatives and problem-based learning oriented; 2) improvement of critical thinking and problem solving skills of SMP MARS Pematang Siantar Class VIII students by using teaching materials developed by implementing virtual manipulative and problem based learning oriented. This research is a development research. The development model used in this study is the Thiagarajan model. The results showed that: 1) the teaching materials developed by implementing virtual manipulative and problem-based learning oriented were declared valid, practical and effective; 2) there is an increase in critical thinking and problem solving skills for students of SMP MARS Pematang Siantar Class VIII by using teaching materials developed by implementing virtual manipulative and problem-oriented base learning. In the first trial there was an increase in the value of critical thinking skills of 0.35 and the value of problem solving abilities of 0.44 with moderate criteria. Likewise, in the second trial there was an increase in the value of critical thinking skills of 0.42 and the value of problem-solving abilities of 0.53 with moderate criteria.

Keyword: Virtual Manipulative, Problem Based Learning, Critical Thinking Ability, Problem Solving

1. Introduction

Problem-solving skills are one of the topics covered in math classes. One of the primary objectives of learning mathematics, according to NCTM in Rofiqoh, et al., is for pupils to develop their problem-solving abilities. Since learning and solving issues allows students to practice applying their prior knowledge and skills to the solution of non-routine situations, problem solving is a crucial component of the mathematics curriculum [1].

Problem solving ability is one of the high-level cognitive abilities that enable students to acquire knowledge and skills [2]. This problem-solving ability must be possessed by students because problem-solving skills are the basis of learning mathematics, besides that problem solving is a basic ability in learning mathematics, because mathematics is one part of problem solving. Furthermore, Wibowo explained that problem solving ability is an individual's ability to carry out a series of processes with the aim of solving a problem using concepts that have been mastered previously. Good mathematical problem solving skills will support success in learning mathematics. Problem solving ability is the potential of a student to solve or prove story

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problems and non-routine questions. The non-routine questions are identical to problem-solving abilities because they are one of the abilities that must be possessed or mastered by a student [3].

It is clear from the previous argument that students should place a high value on their ability to solve problems. This is true because students' abilities to read and comprehend story questions, the language of mathematical models, plan calculations from mathematical models, and carry out calculations from non-routine inquiries are all directly tied to their problem-solving abilities. In order for students to practice and integrate the concepts, theorems, and skills they have acquired, problem solving is crucial in mathematics education. In addition, problem solving skills can boost students' creativity, confidence, and mathematical talents [4]. Novitasari and Wilujeng explain that students are expected to have problem solving skills and develop them to deal with problems experienced in their lives, so problem solving skills are very important for students [5].

However, the reality on the ground is in contrast to these theories. When students are solving problem solving problems, students are still difficult to understand the core of the problem well, are unable to understand the subject being asked in the question, still have difficulty in writing down what is known and asked when solving the problem, not being careful in doing arithmetic operations and not writing conclusions from the problem. [6]. The low problem solving ability of students can also be caused by the difficult and scary character of mathematics according to students [7], the challenging and intimidating nature of mathematics might also contribute to pupils' poor problem-solving skills. Additionally, when learning activities are used, kids receive more material information than when thinking activities are used to address their math issues [8].

This is in accordance with the results of the initial observations that the author made at the Private Junior High School MARS Pematang Siantar, based on the results of observations obtained information that the problem solving ability of class VIII students is still low. in the category of understanding the problem 20 students have understood the problem well, 5 students are in the sufficient category and 5 students are in the less category. In the indicator of planning, 15 students are in the less category, 7 students are in the sufficient category and 8 students are in the good category. Furthermore, the indicators of solving the problem, 14 students are in the less category, 8 students are in the sufficient category and 8 students are in the good category. Finally, the indicator rechecked the answers, as many as 25 students were in the less category, and 5 students were in the sufficient category. It can be seen that the problem solving ability of class VIII students of private SMP MARS Pematang Siantar is still dominated by the low category.

In addition to problem solving skills, another ability that must be possessed by students is the ability to think critically. The goal of mastering arithmetic includes critical thinking in large measure. Students are encouraged to have the following skills, according to the Ministry of National Education in Wiliawanto [9]: (1) mathematical skills that can be applied to solving mathematical problems, other subjects' problems, or problems in real life; (2) mathematical skills that can be applied as a tool for communication; (3) mathematical skills that can be applied as a way of reasoning that can be applied in every situation, such as logical thinking, systematic critical thinking, honesty, discipline, in viewing and so on.

Using the capacity for introspective and logical thought, critical thinking seeks to help people decide what to believe or do [10]. Critical thinking is a process of a student in distinguishing and sorting and then grouping and looking for their relationship to the information or problems obtained. A student who thinks critically processes the existing information systematically to state the truth of his opinion. Critical thinking skills are the ability to determine reliable sources,

distinguish between relevant or irrelevant data, identify and analyze assumptions, identify biases and views, and access evidence.

Critical thinking is very important so that students become someone who always thinks actively and positively where students first understand the ins and outs of the real problem, are not easily influenced by the opinions of others, solve problems properly and neatly, and can conclude correct or incorrect information. wrong. Hendriana, et al [11] explained that there are several reasons why students need to have critical thinking skills in learning mathematics. First, mathematical critical thinking skills are contained in the curriculum and learning objectives of mathematics. These include training in logical, systematic, critical, creative, and careful thinking as well as objective thinking, being open to dealing with problems in everyday life and facing an ever-changing future. Second, in critical thinking, a person does not easily accept something he receives without knowing its origin, but he can account for his opinion accompanied by logical reasons.

In contrast to the current notion, however, the reality shows that children still have limited mathematical critical thinking abilities. According to the findings of a study done by Ayu Latifa et al. [12], students' critical thinking abilities are lacking since the learning approach that has been used thus far has not been able to strengthen them and because activities to do so have not been done. Another explanation is that the learning model being utilized seems uninteresting and unchanging. Another reason why students struggle to think critically during the learning process is teacher-centered learning (conventional), which is frequently used in schools today and makes students more passive because the teacher plays a more dominant role [10].

The above is also in line with the results of the initial observations that the author made at the Private Junior High School MARS Pematang Siantar, based on the results of observations obtained information that the mathematical critical thinking ability of class VIII students is still low, students are still not able to give simple explanations, set strategies and tactics, provide explanations further, and draw conclusions.

Applying the Problem Based Learning (PBL) approach is one way to get around pupils' poor problem-solving and critical thinking skills. Students are presented with a problem at the outset of the Problem Based Learning (PBL) learning model, which is followed by a student-centered information search process [13]. Aufa, Saragih and Minarni explained that the problem-based learning model or Problem Based Learning (PBL) is a learning model with a learning approach that brings students closer to authentic and meaningful problems, and makes the basis for students to conduct research, so that learners can create their own knowledge, advance their abilities and inquiry methods, becoming independent and boosting their self-assurance [14].

However, what is happening in the field is inversely proportional to these theories. Safanati and Suhendar [13] explained that in the process of learning mathematics the teacher still uses the lecture and question and answer method. Therefore, students often feel bored and do not dare to answer questions because they do not understand the material well. Marisa [15] shows how the use of learning models may not always be in line with students' needs when it comes to studying mathematics. Students do not accept learning well because they are less engaged in two-way communication with teachers during lessons and prefer to converse with their peers instead of listening to the teacher explain the topic. In addition, the enthusiasm of students in participating in mathematics learning in class is very low, students are sleepy and do not pay attention to when the teacher explains, then like to chat alone with friends when the teacher is explaining the lesson [16].

This is also consistent with the findings of the author's initial investigations into the mathematics learning process at the Private Junior High School MARS Pematang Siantar, the teacher seems to be more dominant in mastering the learning process in the sense that the teacher provides

more information than students seek information. Students look more passive, so they are not active in their learning, students only listen to the teacher's explanation then do the exercises according to the teacher's directions. Learning like this will be monotonous and make students bored so that it has an impact on problem solving skills and students' critical thinking skills.

Another factor that needs to be considered so that the problem solving ability and critical thinking ability of students is increased is the development of teaching materials that are also in accordance with the model and learning media used. Teachers and students employ teaching materials, which are systematically organized resources or subject matter, to aid in the learning process. All items used by teachers to conduct teaching and learning activities in the classroom are referred to as teaching materials.

The reality is that a lot of teachers still haven't done a good job of designing their lesson plans, though. Learning issues that arise during the learning process frequently have a connection to the learning tools and materials. Due to the scarcity of teaching resources, teachers only use textbooks provided by the school when instructing students, and as a result, they rarely give them exercises to test their knowledge [17].

According to the author's findings, few teachers have created teaching resources that make it simpler for pupils to learn independently at the Private Junior High School MARS Pematang Siantar, where the subject teachers exclusively use textbooks to carry out the mathematical learning process. So to help students understand the material, teachers need other teaching materials.

Another solution that can be done by teachers besides using the right learning model in learning mathematics is the use of learning media that can interpret the mathematical concepts more concretely. One of the media in learning is teaching aids. In recent years, the use of computer-based teaching aids has begun to become popular in the community, which is referred to as virtual manipulative teaching aids [18]. Manipulative media are objects, tools, models, or mechanisms that can be used to assist in understanding during the problem solving process related to a mathematical concept or topic [19]. Hanah, et al explained that manipulative materials are physical objects used by students and teachers to describe and discover mathematical concepts [20].

However, it is still the case that teachers struggle to effectively integrate technology into the teaching and learning of mathematics. In reality, children merely copy what the teacher does when studying arithmetic because the teacher rarely gives them the chance to create their own mathematical notions. Additionally, when responding to practice questions supplied by the teacher, pupils are not given the chance to express their thoughts and come up with their own. Many teachers have not developed learning media by utilizing existing software on the computer. In fact, in facing the era of globalization and welcoming the free market era, it is necessary to have the ability to master the development of learning technology, which includes the use of computer software as a medium for learning mathematics, especially in the form of interactive CDs. Mayasari [21] added that the activities that are routinely carried out by teachers still use ordinary learning so that students are more passive. In addition, the availability of media in schools is limited, schools only have a few media and mathematics teaching aids [22].

2. Research Method

The type of research that will be conducted is development research (depelopment research). This research will use Thiagarajan 4-D development model. This research was carried out at the MARS Private Junior High School Pematang Siantar in class VIII students in the even semester of the 2020/2021 academic year. The subjects in this study were class VIII students of the MARS Pematang Siantar Private Junior High School for the 2020/2021 academic year, while

the object in this study was a manipulative virtual teaching material oriented to the PBL model on the material of building flat side spaces of cubes and blocks that were developed.

3. Results and Discussion

3.1. Validity of Teaching Materials Based on Problem Based Learning Models

The teaching materials were deemed to be valid or to have a high degree of validity based on the findings of the validation of the manipulative virtual teaching materials geared toward the proposed problem-based learning model. The teaching materials created are then said to be practical based on all of the teaching materials' valid points. Also valid or valid to a good extent are the findings of the validation of the learning implementation plan (RPP), student book (BS), student worksheet (LKPD), and assessments of critical thinking and problem-solving skills. This demonstrates that the problem-based learning model-focused manipulative virtual teaching materials developed have met the validity standards. In general, it means that the teaching materials developed can meet the demands of learning needs for cube and block building materials. Therefore, it can be said that the problem-based learning model-focused manipulative virtual teaching materials generated in this study have complied with the validity requirements.

3.2. Practical Results of Teaching Materials Based on Problem Based Learning Models

Based on the findings of the experts' evaluations (validators), each validator concluded that with a few minor adjustments, the generated instructional materials may be used. Then, using the observation sheet on the implementation of learning using developed manipulative virtual teaching materials oriented to the problem-based learning model, which was distributed to two observers at each trial meeting I and II, the results showed that in the first trial, the score for observing the implementation of learning did not meet the practical criteria, specifically with a score of 2.96 in the low category. Furthermore, in the second trial, a score of 3.63 was obtained in the high category.

3.3. Results of the Effectiveness of Teaching Materials Based on Problem Based Learning Models

a. Critical Thinking Ability Test Achievement and Student Problem Solving Ability

The students' critical thinking and problem-solving abilities were deemed to have met the conventional completeness criteria based on the findings of the test analysis in the first and second trials. This is due to the material and problems that exist in the teaching materials developed in accordance with the conditions of the student learning environment. By using this teaching material, students will more easily understand the material of building space (cubes and blocks). In the first trial, students' performance on the final test of their critical thinking and problem-solving skills was 36.7% successful, with 11 students receiving a certificate of completion. Therefore, it can be stated that the use of manipulative virtual teaching materials created for the problem-based learning model did not match the requirements for obtaining classical completeness (>80%) in the first trial. However, in the second trial, 27 students were judged complete since their performance on the final exam of their critical thinking and problem-solving abilities met the required standards, or 90%. Therefore, it can be said that the problem-based learning model-focused manipulative virtual teaching materials have met the efficacy criteria in the area of developing students' critical thinking skills.

b. Deal Time Achievement

According to a study of the findings from the first trial's observation of student activity, the average percentage of student activity deal time success for the trial's three sessions was 20.98%, 18.19%, 19.93%, 23.78%, 8.74%, and 8.74%. The average student activity deal time achievement percentage for the four meetings in the second experiment was 22.20%, 18.52%, 23.84%, 23.28%, 7.14%, and 5.02%. These findings indicate that every student activity in the second trial complies with the required deal time %.

c. Student Response

Students in the trial and trial I expressed interest in the generated instructional materials, according to analysis of the findings of the student replies previously mentioned. The average score of student replies demonstrating interest in learning with the created instructional materials demonstrates this. According to the results of the student response survey, the first trial's score was 82%, while the second trial's score was 91%. Therefore, it can be inferred from the students' responses to engaging instructional materials built on the successfully created problem-based learning paradigm. According to Ismail, Abrar, Nur, Suharti and Halimah (2021: 1) the application of teaching materials based on problem based learning models received a positive response from students. Furthermore, the results of research by Nuraeni Indrayanti and Sukmaningthias (2021: 65) that student responses to the application of problem-based learning-based teaching materials obtained an average score of 3.29 or in the positive category.

3.4. Improving Students' Critical Thinking and Problem Solving Skills

According to the normalized gain index, the value of critical thinking skills increased by 0.35 and the value of problem-solving skills increased by 0.44 with moderate criteria in the first trial. The value of critical thinking skills increased by 0.42 and the value of problem-solving skills increased by 0.53 with moderate criteria in the second trial. It follows that the produced manipulative virtual teaching resources based on the problem-based learning model can help students become more adept at critical thinking and problem-solving.

4. Conclusion

a. The teaching materials developed by implementing virtual manipulative and problem-based learning oriented are declared valid, practical and effective;

b. Using instructional materials created by implementing virtual manipulative and problem-oriented base learning, SMP MARS Pematang Siantar Class VIII students' critical thinking and problem-solving abilities improved. With intermediate criteria, there was a 0.35 increase in the value of critical thinking abilities and a 0.44 increase in the value of problem-solving skills in the first trial. The value of critical thinking skills increased by 0.42 and the value of problem-solving skills increased by 0.53 with moderate criteria in the second trial.

References

[1] Rofiqoh, Z.dkk. 2016. Analisis Kemampuan Pemecahan Masalah Siswa Kelas X Dalam Pembelajaran Discovery Learning Berdasarkan Gaya Belajar Siswa. *Journal UJME.* (5) (1)

[2] Helmi, dkk. 2017. Pengaruh Pendekatan Berpikir Kausalitik Ber-Scafollding Tipe 2B Termodifikasi Berbantuan LKS Terhadap kemampuan Pemecahan Masalah Fluida Dinamis Siswa. *Jurnal Pendidikan Fisika dan Teknologi.* (3) (1), 68-75

[3] Wibowo Sri Anggun Budi, dkk. 2016. Penerapan Metode Discovery Learning Dengan Media Visual Dalam Peningkatan Kemampuan Pemecahan Masalah Pada Pembelajaran Matematika Siswa Kelas IV SDN 2 Karangsari Tahun Ajaran 2015/2016. *Jurnal Kalam Cendikia.* (4) (1)
[4] Tambunan, Hardi. 2019. The Effectiveness Of The Problem Solving Startegy and The Scientific Approach To Students' Mathematical Capabilities In High Order Thinking Skills. *IEJME.* (14) (2)
[5] Novitasari dan Wilujeng. 2018. Analisis Kemampuan Pemecahan Masalah Matematika Siswa SMP Negeri 10 Tangerang. *Jurnal Prima.* (2) (2)
[6] Setyaningtyas, Puri, dkk. 2019. Efektivitas Brain Based Learning Terhadap Kemampuan pemecahan Masalah matematika Anak Usia 5 – 6 Tahun. *Jurnal Kumara Cendikia.* (7) (3)
[7] Fitria, Neng Fla Nisa, dkk. 2018. Analisis Kemampuan pemecahan Masalah Matematik Siswa SMP Dengan Materi Sigitiga dan Segiempat. *Jurnal Edumatica.* (8) (1), 49-57
[8] Febriani, Winarti Dwi, dkk. 2019. Pengaruh Pembelajaran Realistic Mathematics Education dan Direct Instruction Terhadap Kemampuan pemecahan Masalah dan Komunikasi Matematis Siswa SD. *Jurnal Tunas Bangsa.*(6) (2), 151-161
[9] Wiliawanto, Windi, dkk. 2019. Penerapan Strategi Pembelajaran Aktif Question Student Have Untuk Meningkatkan Kemampuan Berpikir Kritis Matematik Siswa SMK. *Jurnal Cendikia.* (3) (1)
[10] Nurkholifah, Siti, dkk. 2018. Hubungan antara Self Confidence dengan Kemampuan Berpikir Kritis Siswa dalam Pembelajaran Matematika. *Jurnal Formatif* . (8) (1)
[11] Hendriana. 2018. *Hard Skills dan Soft Skills*. Bandung : Rafika Aditama.
[12] Ayu Latifa, Baiq Rizkia, dkk. 2017. Pengaruh Model Learning Cycle (Engange, Explore, Explain, Elaboration and Evaluate), Terhadap Kemmapuan Berpikir Kritis Peserta Didik Kelas X MAN 1 Mataram. *Jurnal Pendidikan Fisika dan Teknologi*. (3) (1), 61-67
[13] Safangati, Alfi dan Suhendar. 2020. Penerapan Model Problem Based Learning Berbantu Strategi Game Mazelbirin dan Puzzle Untuk Meningkatkan Pemahaman Konsep Matematika Siswa Kelas X MIPA SMA N 1 Badegan. *Jurnal Edupedia.* (4) (1)
[14] Aufa, Saragih dan Minarni. 2016. Development of Learning Devices through Problem Based Learning Model Based on the Context of Aceh Cultural to Improve Mathematical Communication Skills and Social Skills of SMPN 1 Muara Batu Students. *Journal of Education and Practice.* (7) (24), 232-248
[15] Marisa. 2020. Penerapan Model Pembelajaran Problem Based Learning Untuk Meningkatkan Kemampuan Berpikir kritis Serta Hasil Belajar Pada Mata Pelajaran Matematika Siswa Kelas 5 SD Negeri Mangunsari 01. *Jurnal Pendidikan Tambusai.* (4) (1)
[16] Tomas dan Prasetyo, 2020. Penerapan Model Pembelajaran PBL Terintegrasi Stem Untuk Meningkatkan Aktivitas Dan Hasil Belajar Peserta Didik Di Kelas XII IPA 5 SMAN 7 Padang. *Jurnal Berkala Ilmiah Pendidikan Fisika.* (13) (3)
[17] Rozi Nasution, Sari Wahyuni. 2018. Penerapan Model Inkuiri Terbimbing (Guided Inquiry) Dalam Meningkatkan Kemampuan Berpikir Kritis Pada Pembelajaran Fisika. *Journal Education and Development*, (3) (1)
[18] Kania, Nia. 2016. Efektivitas Penggunaan Alat peraga Maya (*Virtual Manipulative). Jurnal Theorems.* (1) (1)
[19] Ardianto, Widi, dkk. 2017. Pembelajaran Sanitifik Berbantuan Media Manipulatif Untuk Memahamkan Konsep Penjumlahan dan Pengurangan Bilangan Bulat. *Jurnal Pendidikan.* (2) (5), 694-705
[20] Hanah, Raey, dkk. 2016. Penggunaan Bahan Manipulatif Untuk Memahamkan Materi Peluang Pada Siswa SMP Dengan Pendekatan Pendidikan Matematika Reaslistik. *Jurnal Pendiidkan.* (1) (5), 927-939

[21] Maya, Wahyunarti. 2019. Pengembangan Modul Berbasis Penelitian pencegahan P. Berghei Pada Mus Musculus Terhadap Berpikir Kritis Mahasiswa. *Jurnal Pendipa.* (3) (2)
[22] Mashita. 2018. Penerapan Model *Think Pair Share* Untuk Meningkatkan Kualitas Pembelajaran Operasi Bilangan Dengan Bantuan Media Manipulatif. *Jurnal Pendidikan Tambusai.* (2) (1)