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Development of mathematics learning tools through scientific approach with problem based learning (PBL) settings to improve motivation and learning achievement

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Abstract

This research aimed at obtaining a scientific learning tool in the scientific approach with a valid, practical and effective problem based learning (PBL) setting. This development research was carried out according to Plomp & Nieveen (2010), i.e. (1) initial phase, (2) prototype phase, and (3) assessment phase (semi-summative evaluation). The learning tools consisted of student books and teacher manuals. This research was carried out at SMP Negeri 4 Mengwi. Learning device quality data was collected with validation sheets, learning device implementation sheets, student response questionnaires and teacher responses, motivation questionnaires and mathematics learning achievement tests. The characteristics of student books are (1) learning begins with real problems in everyday life that related to the material being studied; (2) students are given the opportunity to ask questions from the observations that have been done and answered by their colleagues; (3) discuss and seek solutions from the problem of "come thinking!" which has been given in groups; (4) presenting the results of the discussion, thus the students can give opinions, ask questions, and respond; (5) there is a summary of each material in each chapter. Characteristics of the teacher's manuals are (1) the existence of an initial narrative that describes the framework of the material to be studied; (2) contains the way the teacher facilitates learning in each part of the material; (3) include the student's book thus the teacher does not need to bring the students' book; (4) there is an alternative solution to the problems and those problems are given in the student book; (5) the planting concept is done through problem based learning. The results showed that learning devices met the criteria: (1) valid, with an average validity was 3.62 based on the opinions of two validators, (2) practical, with an average practicality was 3.13 based on the implementation of learning devices from the viewer's opinion, teachers, and students, (3) effective, with an average learning motivation of 81.9 and the average results of the 80.9 student learning achievement test were based on students' completeness in learning material that exceeds the defined KKM by showing increased in the motivation and student learning achievement.

Keywords: *learning tools; scientific approach; problem based learning (PBL); motivation, learning achievement*

Introduction

Mathematics is science from various disciplines that have an important role in developing the human mindset (Suherman, 2003). Mathematics lessons have been given from basic education to the highest level of education. Suherman (1993) suggested that "students need mathematics to meet practical needs and solve their problems in everyday life, such as counting, calculating content and weight, collecting, processing, presenting and interpreting data, and using a calculator or computer" Mathematics can also be applied in other fields of science such as physics, chemistry, pharmacy, economics and other fields of science.

In mathematics learning at the junior high school level, students are directed to have the ability to think logically, analytically, systematically, critically and creatively and have an attitude of respecting mathematics and its usefulness in life. This is in line with the learning

objectives of mathematics established in the 2013 curriculum. In the 2013 curriculum, it is revealed that the graduates' competence in the field of mathematics studies is to bring about an increase and balance of soft skills and hard skills that include aspects of competency in attitudes, knowledge, and skills in mathematics. But in reality, the purpose of mathematics learning established by the 2013 curriculum has not been realized optimally in mathematics learning in the classroom.

After observations and interviews with the teachers at SMP Negeri 4 Mengwi, we found several obstacles: (1) smart students dominated learning activities, resulting in other students were less actively involved and most students were shy to ask when finding difficulties in understanding the concept of learning; (2) students had lack opportunity to share information with their friends thus the activities of communicating to the scientific approach in the 2013 curriculum were not working properly; (3) students books were not well designed and less related to real life thus the students were not actively involved in learning; (4) students had low learning motivation. These problems arose because of the lack of a learning process and learning tools. Students low motivation in learning, thus they hardly understand and respond to materials and problems. Therefore, with the activeness of asking questions, answering questions, expressing ideas, and creativity in solving mathematical problems, students' abilities in learning would increase. Mathematics learning should involve students fully, and in learning related to real life; thus students were motivated in learning.

To improve student motivation and learning achievement in the field implementation, the availability of learning tools was of importance. With the learning tools, students would easily understand and explore the problems that exist in their lives. Learning tools were very necessary for carrying out learning, thus the process could be directed according to the learning approach used. Setianingsih, Aini, & Kristanti (2016) concluded that students' mathematics learning achievement could be improved through a scientific approach in the learning process. Wibowo (2017) added that the scientific learning approach was effective in learning achievement.

To produce learning tools related to daily life, problem based learning (PBL) setting should be applied. PBL used real-world context (Pratama, Lestari, & Jailani, 2018). PBL began by giving problems related to the real world. Students were actively identified and formulated problems, studied and searched for material related to the problem, and presented the results of the discussion. Meanwhile, the teacher acted as a facilitator. PBL stages which

were carried out systematically would eventually motivated students and were able to develop students' abilities in solving problems.

Considering the effectiveness of PBL in motivating students, we proposed this research to develop learning tools in mathematics through PBL setting to improve learning motivation and achievement.

Materials and Methods

This development research aimed at developing mathematics learning tools with PBL settings, especially in class VII junior high school. The outputs were lesson plans, student books, and teacher's manuals. The phases of this research were (1) preliminary research, (2) prototyping (iteration process analysis, design and development, formative and revised evaluation), and (3) assessment (semi summative assessment). The study was conducted at SMP Negeri 4 Mengwi with subjects were students of class VII.

At the preliminary research phase, the following activities were carried out: (1) at the initial stage, researchers required data related to school needs, school conditions, conditions of students and teachers, supporting facilities and environmental support; (2) conducting studies related to the content standards and mathematics books of class VII that implemented the 2013 curriculum, reviewing the learning process carried out in the classroom;. (3) interviewing mathematics teacher in class VII to identify the constraints experienced during learning; (4) reviewing learning devices used in mathematics learning in class.

The activities in the prototyping phase were: (1) designing student books, teacher’s manuals and research instruments, and preparing an initial draft (prototype I) of learning mathematics with PBL settings; (2) validating prototype I which included conformity with core competencies, basic competencies, concepts, conformity with the principles and characteristics of mathematics learning with PBL settings to increase motivation and learning achievement of class VII grade; (3) revising the results of the expert test, thus a prototype II could be obtained with PBL settings to improve the motivation and learning achievement of class VII students with valid quality; (4) conducting limited trials and made a revision (prototype III); (5) carrying out field I trials to improve product quality or obtained the characteristics of scientific learning with PBL settings, and practical and effective books, resulted in prototype IV.

In the assessment phase, we carried out field test II in one class. At the end of the trial, the assessment was carried out in the form of motivational questionnaires and learning

achievement tests. The results of the study were used as revision material to obtain a scientific learning tool with PBL setting which was practical and effective (final product).

Results and Discussion

In the first stage of learning tools development, preliminary research was carried out by analyzing the situation and identifying problems that occur during the learning process, analysis of material and conditions of students. The activities carried out were observing mathematics learning that took place in class, learning tools arranged by the teacher, and conducting interviews with class VII teachers. This was done to identify problems during learning. The results of the implementation of preliminary research indicated that there are obstacles in learning. The prototype was prepared to produce draft learning tools in the form of lesson plans, student books and teacher's manuals.

In the second stage, we compiled student books, teacher's manuals, and supporting instruments. The other instruments were observation sheets for learning tools, student response questionnaires, teacher response questionnaires, learning motivation questionnaires, and students' learning achievement tests in multiple choice questions. The initial draft of the learning device and the instrument was then called Prototype I which was validated before the implementation to find out the quality of the prototype developed. The revision was then called Prototype II.

The trial process in this study was carried out three times, i.e., limited trials, field I trials, while field trials II were carried out in the assessment phase. The limited trial was carried out in class VII A with ten students with heterogeneous abilities. The focus of this trial was to get an overview of the implementation of learning with mathematical learning tools. In this trial, a formative evaluation carried out involving the researchers, the teachers, and ten students, using questionnaires and observations. The results were then used to revise Prototype II to produce Prototype III. The field I trials were carried out in class VII B with 30 students. The focus of this trial was to improve product quality. In this trial a formative evaluation was carried out involving the researchers, the teachers, and all class VII B students, using observation, questionnaires, and evaluation tests. The result of the revision was called Prototype IV. An assessment phase, in field II trials, were in principle the same as the activities carried out in the field I trials. However, at the end of the learning, semi-summative tests were carried out consisting of 20 objective questions for the achievement of learning objectives with the application and use of products. This trial was carried out in class VII C with 27 students. The focus of this trial was to obtain a valid, practical, and effective

learning material. In this trial, semi-summative evaluation was performed involving the researchers, the teachers, and all class VII C students. In this trial, we used several assessments, i.e., observation, learning motivation questionnaire, and learning achievement tests to revise Prototype IV to produce the final product.

Before this research, teachers were using teacher-centered and did not involve students. After the learning tools had been compiled and implemented in the learning process, students were introduced to the phenomena in daily life. During the implementation of the learning tools, several learning characteristics were found that differentiated the learning process carried out during the implementation of scientific learning mathematics tools with the developed PBL setting. The learning tools: (1) linked the study materials with students' daily problems, (2) provided opportunities for students to work in groups, (3) invited students to think actively through various mathematics problems presented.

Learning tools developed have followed Nieeven criteria which include validity, practicality, and effectiveness. The learning tools was considered valid because: (1) the learning tools were developed according to Plomp's model, (2) the learning tools were developed according to core competencies and basic competencies; (3) the learning tools were developed in PBL settings, (4) the learning tools had a clear systematics student-oriented, clear instructions, easy to use, and easy to understand. Based on the questionnaires, the learning tools were classified as very practical.

There was an increase in the practicality of the learning tools after each trial. The implementation of the learning tools was an increase from practical in the field I trial to very practical in field II trial. Similarly, student books and teacher's manual were also increased in their practicality, i.e., from practical in the field I trial to very practical in field II trial. Therefore, the developed learning tools fulfilled the practical aspects. There were not many difficulties experienced by both students and teachers in using lesson plans, student books, and teacher's manuals. It met the practical aspects because: (1) the student books were easy to use because of the systematic arrangement of materials, instructions and language were easy to understand, contents were related to the level of student development, and problems were related to students' daily lives. Students were enthusiastic in reading and discussing the problems in the student book; (2) the teacher's manual was easy to use because it was arranged systematically and contained the substance of the student books, contained instructions for the implementation of learning, contained answers to problems in the student book that can be used as a guide by the teacher and the use of language was easy to

understand; (3) learning tools emphasized student-centered learning and positioned the teacher as a facilitator; (4) discussion on the effectiveness of learning tools.

Additionally, we also measured the effectiveness of learning tools which were used to see the increase in student motivation and learning achievement after using the tools. On average, students' motivation and learning achievement showed an increasing score thus considered in the good category. Most students showed increased motivation and learning achievement, and were able to work in groups according to PBL model. Students were able to express ideas, ask questions, present the results, and follow each activity on the scientific approach (observe, ask, try, reason and communicate).

There were also other things that made the developed learning tools were effective. The application of the scientific approach to student books could guarantee an increase in student learning motivation. Students were invited to be actively involved in learning such as observing various examples, expressing questions, answering questions, solving a mathematical problem, and training students in communication. Students activities to solve problems in groups through PBL learning could provide opportunities for students to discuss and share ideas; thus the students would be actively involved in groups. Contextual problems in student books provided opportunities for students to find concepts; thus the students would understand the material they were learning, and eventually, would improve learning achievement.

Conclusion

The lesson plan, student books, and teacher's manual in mathematics were developed through problem based learning (PBL) setting. After the trials, the learning tools were considered as effective and practical. Using these tools, both teachers and students found that the learning process was much better and students were involved more actively, thus increasing their learning motivation and achievement.

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