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Development of problem-solving-oriented mathematics learning tools with TANDUR setting to improve mathematics learning outcomes

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Abstract

This study aimed to develop and produce a problem-solving-oriented mathematics learning tool with "tumbuhkan", "alami", "namai", "demonstrasikan", ulangi", "rayakan" (grow, experience, name, demonstrate, repeat, and celebrate) (TANDUR) setting to obtain a valid, practical and effective learning tool, and improving mathematics learning outcomes of class X Stone-Concrete Construction at SMK Negeri 1 Denpasar. This research was development research with problem-oriented learning model through TANDUR setting using learning support tools which included student manual, teacher manual and RPP. The development of learning tools followed the development procedure of Plom model which consists of 3 phases, namely: 1) Preliminary Research Phase, 2) Prototyping Phase (iteration process of analysis, design and development, formative evaluation and revision), 3) Assessment Phase (semi summative assessment). The subjects of the study were 28 students of class X KB2 at SMK Negeri 1 Denpasar. The required research data included validity, practicality and effectiveness data of learning tools. The validity of learning devices was tested through expert assessment. While the practicality and effectiveness of learning tools were tested through field trials. The results showed that the developed learning tools were valid with the average score of validation on 1) the student book was 3.7 which categorized very valid, 2) the teacher manual 3.8 which categories as very valid. The practicality of the developed learning tools on 1) implementation of learning devices conducted on field trials I averaging 3.1 which categorized as practical, 2) implementation of learning devices on field II averaging 3.2 which categorized as practical. The developed learning devices were effective with the average of the test score of the learning result on the field trial I was 78.92 with the good category, and the results of field study II was 86.07 with the excellent category which had exceeded the value of the Minimum Completion Criteria.

Keywords: *problem-solving-oriented mathematics learning tools; TANDUR setting; learning outcomes*

Introduction

Developing students' abilities through learning can be done by using learning strategies that involve students actively in the learning process; focusing instruction on the learning process rather than relying solely on content; and using assessment techniques which gives students an intellectual challenge and not the ability to memorize specific procedures or concepts Through mathematics learning, teachers need to design learning that actively involves students in learning processes. The teacher can carry out problem-solving-oriented learning, where students must understand mathematical concepts through problem solving. From the experiences gained by students, mathematics problem solving process enables students to develop their problem solving abilities.

One of the problems solving oriented learning is *tumbuhkan, alami, namai, demonstrasikan, ulangi, rayakan* (grow, experience, name, demonstrate, repeat, and

celebrate) (TANDUR). The TANDUR model emphasizes the creation of a learning environment and designing learning experiences that are part of the learning process. The model provides opportunities for students to learn according to their abilities, how to use an interactive method to assess what they know, identify what they want to know, evaluate what students can do. This is done by taking the students' initial knowledge into account and utilizing that knowledge as a foundation in subsequent learning, thus the role of the teacher is as a facilitator only to facilitate students in mastering the study materials. This is related to the perspective of constructivism, which is student-centered learning, not teacher-centered learning.

TANDUR can help students to achieve a better understanding of mathematical concepts and their applications by linking their knowledge with the study materials, thus that learning becomes a link and matches students' real life. The implementation of TANDUR will develop students' scientific performance at the experiment and demonstration phase. Through this phase, students get the opportunity to be actively involved in learning by experiencing what they have learned through demonstrations and experiments themselves. Students are also given the chance to perform their work method, thus they would actively interact in the learning process.

TANDUR is a learning design that is expected to make students interested in the study, provide experiences directly to students and try to make realistic contents of the lesson (De Porter, et. al, 2009). Learning by using the TANDUR model is done by developing students' interests by giving motivation to students, thus they have an image of the lessons they experience directly. Wardani et al., (2007) stated that learning outcomes were a person's ability acquired after learning activities. Sujana (2004) stated that student learning outcomes were essentially the behavioral changes and as feedback to improve the teaching and learning process.

TANDUR was staged in quantum teaching model (De Porter et al., 2009). Implementing this model would eventually increase students' learning outcomes (Fahmi Irawan & Kholis, 2015; Hidayana & Juliani, 2014; Khairani & Ismah, 2017; Susiani, 2013), learning achievement (Handayani & Perdata, 2014; Sukerthi, Dantes, & Yudana, 2013), learning interests (Septina, Dewi, Suarni, & Widiana, 2014), and learning activity (Handayani & Perdata, 2014). Moreover, the model would also improve socio-emotional skills (Susiani, 2013), science literation (Sukerthi et al., 2013), problem solving ability (E, Widiyaningsih. E, 2013), multi-representation ability (Ningrum, Mahardika, & Gani, 2015), and creativity and memory (Sujatmika, Hasanah, & Hakim, 2018) among students.

Therefore, it is essential to develop learning tools to help teachers and students in implementing the model. This study aims at producing a problem-solving-oriented mathematics learning tool with TANDUR setting to obtain a valid, practical, and effective learning tool, and to improve students' learning outcomes in mathematics.

Materials and Methods

This research was development research because the purpose of this study was to develop a mathematics learning model which was a problem-solving oriented by TANDUR settings with learning support devices that included student manual books, teacher manual books, and lesson plans to increase student activity and learning outcomes. The subjects in this study were class X students majoring in the building. The development of learning tools in this study followed the learning development procedures, i.e., 1) preliminary research phase; 2) prototyping phase (analytical literacy process, design and development, formative evaluation and revised); 3) assessment phase (semi summative assessment) (Plom, 2010). The assessed aspects of this study were aspects of validity, practicality, and effectiveness. The instruments used in this study are: (1) validity of learning devices sheet to measure construction validity of experts; (2) observation sheet for the implementation of learning devices; (3) questionnaire of students' response towards the learning to measure the practicality aspect of learning devices; (4) questionnaire of teachers' responses towards the learning to measure the practicality of learning devices and (5) test of learning outcomes to measure the effectiveness of the developed learning tools. The data was then processed descriptively.

The quality of the equipment developed in this study was assessed in terms of its validity, practicality, and effectiveness. Therefore, to determine the quality of the developed devices, three kinds of data are needed, i.e., validity, practicality, and effectivity of developed learning tools. To obtain the research data, it was carried out through questionnaires, observations, and tests.

The validity of learning devices was measured by content validity and construct validity. Content validity was seen from the development process of the compatibility of learning devices developed with supporting theories, which are assessed by the researchers. In this study, construct validity was evaluated based on the relevance and compatibility of the components in the learning device with the learning theory used as a foundation. The construct validity was determined based on experts' opinion. Each expert was given a validity sheet containing several aspects which include characteristics of learning devices and

content of learning tools. In the validation sheet, validator opinion was categorized into four rating scales, i.e., very good (score 4), good (score 3), less (score 2), very less (score 1). Each expert then assesses the suitability of the learning device and the aspects contained in the validation sheet, by checking one of the rating scales listed in the validation sheet column. The validity of learning devices is determined by converting the total average score into qualitative values using Table 1.

The practicality of learning devices was measured based on the implementation of the learning tools in the classroom. Data regarding the practicality of the developed learning tools were obtained from observations of the learning device's feasibility, questionnaires of the teacher's response to the learning device, and questionnaires of students' responses to the learning device after participating in the learning. Observation of the feasibility of learning devices was done by observing each aspect found in the observation sheet at each meeting. In the observation sheet, the student response sheet, and the teacher response sheet, the assessment was categorized into four rating scales: very good (score 4), good (score 3), less (score 2), very less (score 1). The obtained data is then analyzed and to see the practicality value of the learning tools developed, the obtained average score was converted based on Table 2.

The effectiveness of learning devices was measured based on the accomplishment of learning objectives that used developed learning tools. Assessing the effectiveness of learning devices was done by collecting data through tests of mathematical communication skills in the form of a descriptive question. The scoring to each question was seen from the indicators of the mathematics learning outcomes test.

Table 1. Validity criteria for learning tools

Score	Criteria
$3.5 \leq Sr \leq 4.0$	Very valid
$2.5 \leq Sr < 3.5$	Valid
$1.5 \leq Sr < 2.5$	Invalid
$1.0 \leq Sr < 1.5$	Highly Invalid

Table 2. Criteria for practical learning tools

Score	Criteria
$3.5 \leq Sr \leq 4.0$	Very practical
$2.5 \leq Sr < 3.5$	Practical
$1.5 \leq Sr < 2.5$	Not practical
$1.0 \leq Sr < 1.5$	Very not practical

To see the value of the effectiveness of the developed learning devices based on the data of mathematics learning outcomes, the data is converted based on Table 3.

Results and Discussion

Result showed that the developed learning tools were valid. The Student Book and the Teacher's Guide Book achieved the average value of 3.7 (very valid) and 3.8 (very valid), respectively (Table 4).

The practicality of the learning device in this study was assessed based on its feasibility of learning using developed learning tools during the mathematics learning activities that took place in the classroom. There was an increase in the average score starting from the limited trial to the field trial 2. In this study, the trial was only carried out until the field trial 2. It can be seen that the average observing score for the learning implementation in field trials 2 was 3.2. Based on the established criteria, the developed learning tools are included in the practical criteria, because Sr was in the range of $2.5 \leq Sr < 3.5$ (Table 5).

Data on student responses were filled by eight students in a limited trial, 28 students in field trial 1, and 28 students in field trial 2. There is an increase in the average score starting from the limited trial to the field trial 2. In this study, the trial was only carried out until the field trial 2. It was seen that the average score of students' responses to learning devices in field trial 2 was 3.3.

Table 3. Conversion Scores of Mathematics Learning Outcomes

Score	Criteria
$X < 75$	Less
$X \geq 75$	Good
$X \geq 86$	Very Good

Table 4. The validity of learning devices

No	Learning Tools	Mean	Criteria
1	Student manual book	3.7	very valid
2	Teacher manual book	3.8	very valid

Table 5. Observation result for the implementation of learning tools

No	Observation	Average Score of Observer 1	Average Score of Observer 2	Total Average Score	Criteria
1	Limited Trial	2.9	3.0	2.9	Practical
2	Field Trial 1	3.1	3.1	3.1	Practical
3	Field Trial 2	3.2	3.2	3.2	Practical

Based on the predetermined criteria, the developed learning tools are included in the practical category, because Sr was in the range of $2.5 \leq Sr < 3.5$ (Table 6).

Data regarding the teacher's response to the learning device was filled by teachers who carry out the learning during limited trials, field trial 1, and field trials 2. There was an increase in the average score starting from limited trials to field trials 2. In this study, the trial was only carried out until the field trial 2. It was seen that the average score of the teacher's response to the learning device in field trial 2 was 3.6. Based on the predetermined criteria, the developed learning tools were categorized as a very practical category, because Sr was in the range of $3.5 \leq Sr < 4.0$ (Table 7).

The effectiveness of the product could be seen from the accomplishment of the learning objectives with the application and usage of the products. To assess the effectiveness of learning devices, a test of mathematics learning outcomes was used. According to Plomp (2010), the assessment of students' mathematics learning outcomes was carried out by giving a semi summative test after the 4^{th} draft was tested in field trial 1 and field trial 2 to see the effectiveness of the product which consisted of 10 descriptive questions. This test was previously tried on heterogeneous classes with the classes used in this research. From the results of the analysis, the test of mathematics learning outcomes had been valid and reliable. Due to the average test score in field trial 1 is 78.92, the effectiveness of the product was categorized as "good" because this value lies within the interval $\bar{X}>75$ while in the field trial 2, the average test score was 86.07, thus product effectiveness was categorized as “very good" because this value was higher than 86 (Table 8). Hence, it was obtained a valid, practical, and effective mathematics learning tools with problem solving oriented.

Table 6. Students’ response on student books

No	Student Response	Average Score	Criteria
1	Limited Trial	2.9	Practical
2	Field Trial 1	3.2	Practical
3	Field Trial 2	3.3	Practical

Table 7. Teacher’s response to learning devices

No	Teacher's response	Average Score	Criteria
1	Limited Trial	2.8	Practical
2	Field Trial 1	3.4	Practical
3	Field Trial 2	3.6	Very practical

The student book consists of book manual instructions, basic competencies, learning objectives, and student learning activities. The student book begins with the problems in students' daily life. This initial knowledge will be easier for problem solving. Learning activity in student books is a group discussion to solve the problems provided. This activity will encourage students to think and to get ideas in formulating the answers and reasonable arguments, providing an assessment and alternative solutions to the problems. The questions in the student's book emphasize more on daily life problems. Through these problems, it is expected to teach students' thinking skills in solving mathematical problems and improve students' understanding of the study materials. Each question has a difficulty level to improve students' understanding. Student learning activities are made based on the problem-oriented learning process by TANDUR setting.

The teacher's instruction book is designed to facilitate the teaching process. It contains instructions and steps that can be implemented by the teacher. The teacher's guidebook consists of book instructions, a brief description of problem solving oriented learning with TANDUR settings, basic competencies, learning objectives, and instructions for implementing problem solving oriented learning by TANDUR setting. By following the instructions, the teacher can apply the learning process properly. A brief description of problem-oriented learning with the TANDUR setting is given; thus the teacher understands and can use the model conveniently. There is a learning phase in the book which is related to problem-oriented learning with TANDUR setting. It is also included the instruction for the implementation of learning which emphasizes the teachers as facilitators in group learning. These instructions will help the teachers to facilitate students in study groups. The teacher provides guidance when students experience difficulties in discussing groups. The teacher's manual contains the substance of student books and alternative solutions to the problems. It facilitates the teachers in carrying out the learning and the teachers can see the learning activities in the student's book and its pages through the teacher's manual without the need to look at the student's book. Alternative solutions to the problems can be used by the teachers as a guide in the discussion. The teacher's instruction manual also provides questions that can be used at the end of the process to evaluate students' understanding.

Table 8. Students' learning outcomes

Test Results	Total Score	Total Score Average	Criteria
Field Trial 1	2210	78,92	Good
Field Trial 2	2410	86,07	Very Good

The problem-solving-oriented mathematics learning tools with TANDUR setting has specific characteristics. Learning begins with exploring the initial knowledge to foster students' interest through the study material and facilitates students in solving the given problems. Motivating students to learn is done through examples of the application of the material that students will learn and provides questions related to the application. The discovery of concepts is made through group discussions with the teacher as a facilitator. Students' understanding is enhanced by training in developing questions related to daily life.

Conclusion

The student's and the teacher's books, as learning tools, have certain characteristics which are useful in developing students' problem solving abilities. The learning process with TANDUR setting is effective to improve students' learning outcomes; therefore, the teacher should consider this approach in the learning process.

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