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Developing teaching materials for Trigonometry in mathematics with realistic orientation using HOTS questions

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Abstract. This research aimed to find the learning characteristics, developing procedure of teaching material, and obtain the effectiveness of Trigonometry material in high school level with realistic mathematics education orienting in higher-order thinking skills (HOTS) questions in improving the activity and learning outcome. The type of research used for this was design research. The obtained product was Trigonometry teaching material with valid, practical, and effective quality. The subject of this research was based on the research stages. Its technique of data collecting used purposive sampling. This was conducted in XI class 1 of Science (MIPA) of SMAN 7 Denpasar academic year 2019/2020. This design research included 3 phases, i.e., preliminary research, prototyping, and assessment. The development of teaching material regarding the characteristics in realistic mathematics education orienting in HOTS questions with valid, practical, and effective quality. The learning characteristics: used contextual questions, using various models, students' contribution, skill, and good behavior. Teaching material with realistic mathematics education orienting on HOTS questions that have been developed was sufficiently effective in increasing the activity and learning outcome of students.

1. Introduction

Learning is a process obtained from knowledge and experience through behavioral change since there is an interaction of a person and environment in the real world. Mathematics is formed from the result of human thought related to the idea, process, and inductive or deductive consideration. Mathematics learning for students in school is a mindset formation in consideration through thinking about the relationship between definition and concept. It is taught for students to prepare them with logical, analytical, critical, and creative thinking skills in team-work ability. One of the aims of mathematics subjects for students is to comprehend the concept of mathematics, explaining the relationships among concepts, and apply those concepts among logic in broad, accurate, efficient, and properly in solving the problems. Mathematics learning with a realistic approach is the approach that uses daily problems as inspiration resources in concepting and applying the concepts [1]. One of the philosophies bases this realistic mathematics approach is that it is not a compilation or internals of complete process which need for the students to learn at school. Based on the constructivist viewpoint, it is a chance for students to construct mathematics concepts and principles with their ability through an internalization process—teachers in this case as the facilitator [2].

Meanwhile, there are more problems in mathematics learning at school. It is caused by less interest in the learning process where the material in the textbook is used for students commonly only in the form of a prepared formula with some examples of questions which are still abstract. It causes the

understanding of students about the specific concept in trigonometry only limited to memorizing, and its application in daily activities needs to be more emphasized, so it needs the development of teaching material-oriented on HOTS problems.

Based on researcher observation, while observing teachers during the learning process, it found that it was less involving students in finding a concept of trigonometry. The teacher still used conventional learning design, where at the beginning of class, they explained the concept or procedure with a little question-answer session for students, but it seemed that some students were passively responding to those questions. After conveying the first concept, the teacher gave an example of questions and practices. Here it can be observed that not all students do the question but only some students that assumed a smart one to solve. It was the role of the teacher that expected to have the innovation of modifying mathematics learning, so the success or aim of learning a subject can be achieved.

According to observation in XI MIPA of SMAN 7 Denpasar, it was found that the learning process with trigonometry material was far from the expectation. Hence, the student's comprehension of material that has been taught is much less, and it causes their less understanding of trigonometry material. From the result of an interview with some students, the reason of less attractiveness of this learning process are: 1) there is less learning literature that elaborated trigonometry problems with problems in daily life; 2) there are fewer pieces of literature that attract students to be active and able to construct their knowledge in the learning process; 3) there are fewer pieces of literature of trigonometry that has HOTS problems. One of the subjects that related to this mathematics problem with real problems is realistic mathematics education [3].

Sembiring [3] stated that there are five characteristics of realistic mathematics education that can be seen as follows: 1) Using contextual problems; 2) using various models; 3) contribution of students; 4) interactivity; 5) intertwining structure and concept of mathematics. The researcher tried to combine this realistic mathematics education and training their skill in solving the HOTS problem. The HOTS problem is not quit to examine the skill of memorizing, comprehending, and applying but also requires them to analyze, evaluate, and create a model/conclusion from provided information [4].

From the description above, on this occasion, the researcher conducted design research. This design research meant there was a learning of trigonometry in High Schools by using teaching material that has been developed. This is a textbook for students and a book for teachers based on the characteristics of realistic mathematics education oriented on HOTS problems/questions [5]. The produced product would be beneficial for students and teachers in learning trigonometry at school. Therefore, the researcher will develop mathematics teaching material on trigonometry material in High School that is oriented on HOTS problems to improve the learning outcome of students.

2. Methods

The type of research used for this was design research. This research was developed with realistic mathematics education that was oriented on HOTS problems used for students and teachers at school [6]. The subject used for this research was based on the stages of research. Its technique of collecting data was using purposive sampling. This was conducted since design research importantly was finding the lack of and gaining suggestions to improve developed teaching material. This research was conducted in XI class 1 MIPA of SMAN 7 Denpasar academic year 2019/2020. This research began on March 6th, 2019 until November 25th, 2019 so it produced the final product. This design research, including 3 phases: preliminary research, prototyping, and assessment [7].

Instruments used were: 1) validation paper of teaching material to measure validity constructs from experts, 2) observation paper application of teaching material, 3) response of questionnaires from students and mathematics teachers toward teaching material to examine the practicality of developed teaching material, 4) observation paper of students activity during the teaching process, and 5) description test to examine their learning outcomes. The quality of developed teaching material in this research was assessed from three aspects; validity, practicality, and effectivity [8].

The collected data were processed descriptively. The quality of the teaching method produced should fulfill the aspect of validity, practicality, and effectiveness. The validity of teaching material was

including the validity of content and construction. For content validity was assessed by the researcher regarding this developed product already fulfilling the Plomp [9]. The practicality of the teaching method can be seen from the skill of teachers and students in implementing it during the learning process and also the teacher and student's response toward the teaching material. The effectiveness of developed teaching material was shown from student's activity during the learning process and their learning outcomes. To see the effectiveness value of developed teaching material was based on students' learning outcomes of mathematics, then the obtained score was converted. Developed teaching material can be said to fulfill the effective criteria if the score of student's activity minimally achieves the active category or the average score. The interval is $2.5 \leq Sr < 3.5$, and the score for test of students minimally achieving sufficient category or the test result got a score minimally 2.00.

3. Result and discussion

3.1. Result of developing teaching material

Activity in this research has successfully developed Trigonometry teaching material with realistic mathematics education oriented on HOTS problems. The teaching material which successfully developed in this research were: 1) Book for students, and 2) book for teacher. Those were through the trial process in XI MIPA of SMAN 7 Denpasar. The activity that was conducted during the preliminary research phase was analyzing the situation and problem of Trigonometry learning material, which happened in High School. This was held in XI MIPA of SMAN 7 Denpasar as a place of research. To conduct the learning process with this realistic mathematics education oriented on HOTS problems needed a suitable material. Moreover, the available teaching material was not sufficient to do this alternative learning.

In the phase of prototyping (the process of analyzing the literature, design development, formative evaluation, and revision) was conducted the first investigation toward the problems occurred, particularly trigonometry learning material in high school. So the developed product in this research was teaching material with realistic mathematics education oriented on HOTS problems. In the development stage of teaching material, it was obtained design of teaching material in the form of a book or textbook for students and a book for teachers in this research named Draft-I. Book for students was a textbook for students used as guidance in the following activity of trigonometry learning material. This book was developed referred to as a textbook that is usually used by students and teachers during the learning activity of trigonometry material. Book for the teacher was a textbook for teachers used as guidance in conducting the activity of trigonometry learning material. It was developed referred to as curriculum books and textbooks for students.

The produced draft-I then examined the validity by experts. The validation, including compliance with content, presenting technique, physical form, purpose, language, learning activity of realistic mathematics education oriented on HOTS problem. The result of validity by experts was in the form of correction, critics, and suggestions, which were used by the researcher as bases in revising and completing the teaching material that was developed, so it obtained draft-II. Trigonometry teaching material with realistic mathematics education oriented on HOTS problems has valid quality. Besides developed teaching material, practice instruments and the effectiveness of developed teaching material validated to measure the learning outcome of students in solving the problem, validation, and its reliability was examined through field experiment by using a homogenous class with research class [10].

In the pilot experiment, the learning process was conducted six meetings. This was held with the number of students as a subject was six people, where they have skill in high, medium, and low. The focus of this pilot experiment was to obtain the representation of the learning process with the Trigonometry learning process with realistic mathematics education oriented on HOTS problems. Some techniques were applied, such as observation, questionnaires, and tests. Afterward, its result was used to revise draft-II, and this result of revision was named draft-III. The activity conducted in field experiment 1 in its principles was the same as activity conducted in pilot experiment but this trial was held with more students. The field experiment-I was conducted with 36 students. Focus of this trial was

to improve product quality. It was conducted a formative evaluation involving a researcher, a mathematics teacher who teaches Trigonometry, and 36 students. In this field experiment, some techniques of assessment were applied, such as observation, questionnaires, and tests. Then, its result was used to revise draft III and its revision named draft IV and called as the final product. In this research, it obtained the final product in the form of Trigonometry teaching material with realistic mathematics education-oriented HOTS problems with valid, practical, and effective quality.

3.2. Quality analysis of teaching material

To assess the quality of trigonometry teaching material with realistic mathematics education oriented on HOTS problems was used assessment criteria proposed by Nieveen [11]. Three aspects need to be concerned in assessing a product's quality, validity aspect, practical aspect, and effectiveness aspect. Table 1 showed that all of the teaching material had fulfilled the validity aspect. It was shown in the average value of the book for students is 3.3. It showed that the book for students has valid criteria. Book for teachers has an average value of 3.2 and indicates that the teaching material also fulfilled valid criteria.

Table 1. Recapitulation of teaching material validation.

No.	Teaching Material	Average	Criteria
1.	Book for students	3.3	Valid
2.	Book for teachers	3.2	Valid

The practically of teaching material in this research was assessed based on the process of learning by using developing teaching aterial during the conducting activity of learning trigonometry. Two observers held observation of implementing teaching material. Data summary of ibservation result toward the implementation of teaching material can be seen in table 2. It was analyzed that there was an imprvement of average score from limited trial to field experiment 2. In this reserach, the pilot experiment was only held until field experiment 2. It showed that the average score of implementation observation towad field experiment 2 was 3.5 score. So the developed teaching material, including in criteria, was very practical since Sr was in interval $3.5 \leq Sr < 4.0$.

Table 2. Data Summary of observation results in the implementation of teaching material.

No.	Observation	The average score of observer 1	The average score of observer 2	Average score (Sr)	Criteria
1.	Pilot experiment	2.5	2.5	2.5	Practical
2.	Field experiment 1	3.1	3.2	3.1	Practical
3.	Field experiment 2	3.5	3.5	3.5	Very Practical

Six students filled data of student's response result toward teaching material in the pilot experiment, 36 students in field experiment 1, and 36 students in field experiment 2. Data summary of student's responses toward the book for students can be seen in table 3. It showed that the average score of student's response toward teaching material in field experiment 2 was 3.3. So the developed teaching material included the practical category since Sr was in interval $2.5 \leq Sr < 3.5$.

Table 3. Data summary of student's responses toward the book for students.

No.	Students Responses	Average Score (Sr)	Criteria
1.	Pilot experiment	2.8	Practical
2.	Field experiment 1	3.1	Practical
3.	Field experiment 2	3.3	Practical

Data on teacher's response toward teaching material was filled by a teacher who was doing teaching while conducting a pilot experiment, field experiment 1, and field experiment 2 can be seen in table 4. It showed that the average score of teacher responses toward teaching material in field 2 was 3.6. This developed teaching material including in the very practical category since Sr was in interval $3.5 \leq Sr < 4.0$.

Table 4. Summary of the teacher's response data toward the book for the teacher.

No.	Students Response	Average score (Sr)	Criteria
1.	Pilot experiment	3.0	Practical
2.	Field experiment 1	3.4	Practical
3.	Field experiment 2	3.6	Practical

Assessing the effectiveness of develop teaching material was conducted by using assessment regarding the characteristic in realistic mathematics education oriented on HOTS problem [12]. Based on the explanaton of the theoretical study, assessment in realistic mathematics education oriented on HOTS problem was conducted during the learning activity, and the learning outcome of students wa smeasured by using tests such as the description test [13]. Meanwhile, the test was given at teh end of the trial section. The examined material is the whole material of Trigonometry. The student's actiity was observed by two observers, where they were the reseachers themselves. The observation was conducted during the learning activity on each meeting, and the summary of average scored form both observers can be seen in table 5. It showed that on pilot experiment and field experiment 1 the average score was in interval $2.5 \leq Sr < 3.5$. This showed that the applied teaching material was able to make students active in following the calss. Meanwhile, in field experiment 2 the average score was in interval $3.5 \leq Sr \leq 4.0$. Thi showed that the applied teaching material during the whole process of learning was bale to increase students' activity during the class.

Table 5. Summary of observation results from data of student's activity during the learning process.

No.	Observation	The average score of observer 1	The average score of observer 2	Average score (Sr)	Criteria
1.	Pilot experiment	3.4	3.3	3.35	Active
2.	Field experiment 1	3.4	3.5	3.45	Active
3.	Field experiment 2	3.5	3.6	3.6	Very Active

According to the result of observation and the score of learning outcome, it can be concluded that the developed teaching material has fulfilled the effectiveness criteria since it was able to increase student's activity and learning outcomes during the trial process.

3.3. Research achievement

From this research, it was obtained various research achievements, realization of research achievement presented in table as follows: 1) Validation exam toward the content of teaching material was suitable to the characteristics in realistic mathematics education oriented on HOTS problem, 2) Validity exam of the teaching material construction regarding characteristics in realistic mathematics education oriented on HOTS problem, 3) Pilot experiment, teaching material in practice and effective toward 6 students, 4) Field experiment 1, the teaching material was practical and effective for 36 students, 5) Field experiment 2, the teaching material was practical and effective for 36 students, and 6) Product arrangement: validation paper of teaching material to assess the validation constructs from experts, observation paper of teaching material application, questionnaires of students response toward teaching material to assess the practicality of developed teaching material, teachers responses questionnaire to measure the practicality of developed teaching material, observation paper of students activity during

the learning process, description test for measuring the learning outcome of students, textbook for students, and textbook for teacher.

4. Conclusion

This research has successfully developed teaching material regarding characteristics in realistic mathematics education oriented on HOTS problems with valid, practical, and effective quality. Its characteristics were: 1) Using real contextual problems for utilizing reality as a source of trigonometry application. 2) Using various models related to the trigonometry model as a connector for students from informal to a formal situation. 3) Student's contribution was given a chance to develop informal strategies in solving problems that could lead them in solving procedural contributions with teacher assistance; it was expected for students to find their way back. 4) Interactivity, interaction among students, students and teachers and students, and teaching material also should exist during the learning process. 5) Intertwining, structure, and trigonometry concepts were interrelated. Usually, the topic discussion should be explored to support a more meaningful learning process. Characteristics of teaching material for students and book for the teacher contained direction of book usage, mapping concept, sub-subjects, and learning purposes. The main section included a description of trigonometry material, contents arrangement by giving a real problem to the students, it contained several questions discussed by students, so they would be directed to understand the formal concept. In the book for the teacher, it has answer key from problems contained in the book for students. Also, it has direction for the learning process regarding realistic mathematics education oriented on HOTS problems. The books using real problems, using various models, student's contributions, interactivity, intertwining, and learning processes that lead them to create knowledge, skill, and good behavior [14].

Trigonometry teaching materials with realistic mathematics education oriented to HOTS questions have met the criteria of being effective, efficient, and interesting for students. This mathematics teaching material can facilitate students and teachers in learning to understand concepts that have competence in learning objectives. It is hoped that further research on the development of teaching materials will produce other products that are effective, efficient, and have student interest. Teachers should have innovations in developing teaching materials based on an analysis of student's needs to find out difficulties in learning.

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