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Development of Problem-Based Senior High School Mathematics Learning Tools with a Culturally Responsive Teaching Approach

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ABSTRACT

This development research aims to produce valid, practical, and effective senior high school mathematics learning tools through problem-based learning with a Culturally Responsive Teaching approach. The research employed a 4-D model, consisting of the Define, Design, Develop, and Disseminate stages. The research subjects were 36 students in Class X-4 of SMAN 3 Lumajang for the 2022/2023 academic year. The learning tools outcomes included teaching modules, students' worksheets (LKPD), student activity observation sheets, and test questions. The established criteria revealed that the learning tools outcomes were valid, effective, and practical. Hopefully, further research could develop more varied learning tools regarding materials, learning models, and integrated culture.

1. Introduction

One of the branches of knowledge studied by students at school is mathematics. Mathematics cannot be modified because it is a science whose truth is absolute and based on pure deduction, an essential part of mathematical proof. The deduction system explains that a statement is considered valid if the underlying axioms or postulates are also valid (Sinaga et al., 2021). Mathematics is still one of the subjects that is considered difficult by students in elementary and middle school. The learning material is abstract, and the teacher still uses expository methods during the learning process, resulting in some students being unable to understand the material well because of their concrete thinking.

Setiyawan (2017) states that mathematics learning should start by introducing problems or posing real-world problems. Masril et al. (2020) reveal

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that problem-based learning aims to help students develop thinking, problem-solving and intellectual skills, learn how to participate in real-world experiences, and become independent learners.

Interviews with Class X mathematics teachers at SMAN 3 Lumajang showed that teachers experienced difficulties developing problem-based learning tools integrated with culture. Many students also experienced difficulties solving mathematical problems related to data concentration measurement material. In addition, the lack of active participation of students and the unconducive classroom environment during the learning process could make learning activities in the classroom ineffective and inefficient. It made teachers need to facilitate students by using learning models that could actively engage students during the learning process. Learning activities must also be able to explore students' competencies, both in the cognitive, psychomotor, and affective domains. To overcome these problems, teachers can use a problem-based learning model with a *culturally responsive teaching* approach.

The problem-based learning model is a learning model that applies elements of authentic assessment (real or concrete reasoning) comprehensively because it contains elements of finding problems or problem posing as well as solving them (Indrianawati & Wahjudi, 2014). To solve these problems, students will gain knowledge and skills related to the studied material. According to Lubis & Azizan (2018), the problem-based learning model is a learning model that requires students to be more creative, critical, and actively participate in the learning process, especially in solving problems. In line with this, Djonomiarjo (2019) highlights that the problem-solving approach positions the teacher as a facilitator, which focuses on student learning activities. Active learning that engages students, individually and in groups, will be more meaningful because students gain much experience in the learning process. The characteristics of problem-based learning include the application of contextual learning, the presentation of problems that can motivate students to learn, integrated learning (integrity) with unlimited problems, active engagement of students in learning, collaborative cooperation, as well as the development of skills, experience, and concept (Fauzia, 2018).

The *culturally responsive teaching* approach recognizes and accommodates cultural diversity in an environment. Indeed, this approach recognizes and embeds the culture of fellow students in the school curriculum and builds meaningful relationships with the culture of the community. The *culturally responsive teaching* approach is designed to empower students by using meaningful cultural relationships to convey academic social knowledge and attitudes. Maryono et al. (2021) convey that the *culturally responsive teaching* approach involves all students actively participating during learning, a fundamental element of effective teaching. This approach motivates students to learn actively and also encourages them to become independent, namely being able to learn independently, being responsible, tolerant, and respecting differences with other students. Integrating learning and culture in the learning process will create a meaningful learning atmosphere. Arif et al. (2021) also revealed that the culturally responsive teaching approach was a learning method that emphasized the equal rights of every student to receive teaching without distinguishing between their cultural backgrounds. In their research results, Masruroh & Fathani (2024) revealed that mathematics learning tools based on the

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ethnomathematics of the traditional house of the Osing Tribe of Banyuwangi showed that these learning tools could increase student participation in learning activities.

Based on the description above, it is necessary to develop problem-based senior high school mathematics learning tools with a *culturally responsive teaching* approach. The problem-based learning model requires students to play an active role in solving problems. In addition, the culturally responsive teaching-learning approach recognizes and accommodates cultural diversity in the learning environment. The use of this model is expected to increase students' interest and ability in understanding and solving mathematical problems. This research focused on developing problem-based senior high school mathematics learning tools with a *culturally responsive teaching* approach, including teaching modules, students' worksheets, student activity observation sheets, and test questions. Therefore, this research aims to produce valid, practical, and effective mathematics learning tools through problem-based mathematics learning with a culturally responsive approach.

2. Method

This research employed development research methods. The research was carried out in the even semester of the 2022/2023 academic year at SMAN 3 Lumajang. The research subjects were 36 students in class X-4. This development research used a development model consisting of four development stages: *define*, *design*, *develop*, and *disseminate* (Thiagarajan et al., 1974).

The research instruments included teaching modules, student worksheets, student activity observation sheets, and test questions. The validators involved in this research consisted of a mathematics education lecturer and a mathematics teacher. The data analysis technique was descriptive statistical analysis. Data was analyzed based on suggestions and input from validators, which were used as improvement material during the learning tool revision stage. Data analysis was also carried out on students' test results after completing the learning.

Furthermore, the validity level of an instrument was determined by modification outcomes, as mentioned by Hobri (2010), who suggested the steps for determining the V_a value as follows:

a. The validator evaluated each aspect of the research instrument and then determined the average scores of the validation results from the validator for each aspect with the formula:

$$I_i = \frac{\sum_{j=1}^{n} V_{ji}}{n} \quad (1)$$

Where:
I_i : average score of validation results from the validator for each -i aspect
V_{ji} : *j*- validator score data for the -i aspect
n : number of validators

b. Calculating the total average score for each V_a aspect with the formula:

$$V_a = \frac{\sum_{i=1}^{n} I_i}{n} \quad (2)$$

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Where:
V_a: total average score for each aspect
I_i: average score of validation results from the validator for each $-i$ aspect
i: rated aspect
n: number of aspects

c. Determining an instrument's validity level based on the instrument validity level category (modified from Hobri, 2010).

Table 1. Instrument Validity Level Categories

V_a Value	Validity Level
$1 \leq V_a < 1.5$	Invalid
$1.5 \leq V_a < 2$	Less valid
$2 \leq V_a < 2.5$	Fairly Valid
$2.5 \leq V_a < 3$	Valid
$V_a = 3$	Very Valid

The minimum research instrument has met the V_a value with a valid category; thus, it could be used. If the instrument does not meet the valid category, it must be revised and retested until it meets the valid criteria.

Data was analyzed based on the results of student observations and tests after completing each learning cycle. Adopted from Ngalim Purwanto (1992), a formula for analyzing data from student activity observations can be seen below:

$$Observation\ Results\ Score\ (NHO) = \frac{Obtained\ Score}{Maximum\ Score} \times 100\% \quad (3)$$

Based on the percentage value obtained from observations of student activities, interpretation was carried out using the following interpretation categories.

Table 2. Success Level Criteria

Percentage of Student Activities (%)	Category
$85 \leq NHO < 100$	Excellent
$70 \leq NHO < 85$	Good
$55 \leq NHO < 70$	Sufficient
$45 \leq NHO < 55$	Less
$0 \leq NHO < 45$	Poor

Source: modified from Satriani (2016)

The success of student learning outcomes could be measured from those who reached the *Minimum Completeness Criteria* (KKM) of 70 with a minimum classical completeness level of 75% of students who reached the specified KKM (Depdiknas, 2004). The formula for calculating the level of classical learning completeness can be defined as follows:

$$Completeness\ of\ Classical\ Learning = \frac{Total\ of\ Passed\ Students}{Total\ Students} \times 100\% \quad (4)$$

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3. Results and Discussion

A mathematics education lecturer and a mathematics teacher tested the validity of the research instrument. After both validators filled out the validation sheet, the validation results were analyzed using the validation formula and produced a total average score for all aspects (V_a). Furthermore, the total (V_a) values for all aspects categories were given based on Table 1, and the validity level was determined. Based on the results of the validity test, the teaching module was declared valid with a (V_a) value of 2.71, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid. Thus, the teaching module could be implemented. Student worksheets were also declared valid with (V_a) value of 2.81, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid; hence, it could be implemented.

The results of the validity test of the student activity observation sheet obtained a (V_a) value of 2.79, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid so that it could be used for data collection. The results of the validity test of the test questions obtained a (V_a) value of 2.88, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid. Thus, it could be used for data collection. Observations were carried out to perceive students' activities during the learning process. The observation results of students' activities in Class X-4 are:

Table 3. Observation Results of Student Activities

Percentage	Category
94%	Excellent

In addition, student learning outcomes were tested after applying learning tools to data concentration measurement material. The students' learning outcomes in Class X-4 are presented below:

Table 4. Students' Learning Outcomes

Total Students	Total Scores	Average Score	Number of Passed Students	Number of Unpassed Students	Classical Completion Percentage	Classical Achiev-ement (75%)
36	3023	83.97	31	5	86%	Passed

This research employed a 4-D development model that consisted of four stages: *define*, *design*, *develop*, and *disseminate* stages. The definition stage aims to determine and define the requirements needed for learning by analyzing the objectives and limitations of the device material being developed. The process of developing learning tools in this research began with observing and searching for information about mathematics learning carried out in schools. The results of interviews with mathematics teachers showed that teachers experienced difficulties in developing problem-based learning tools that were integrated with culture. Based on the results of initial observations in class, students experienced difficulty in solving mathematical problems related to data concentration measurement material. Therefore, in developing this learning tool, mathematical problems would be given to students through student worksheets, which would be worked on in groups. The learning tool development aims to help students understand the concept of data concentration measures, especially group data

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mode material, as well as improve their ability to solve mathematical problems.

Meanwhile, the *design* stage aims to design a learning device prototype. Preparing tests was the first step in connecting the *define* stage and *design* stage. The tests were prepared based on indicators of competency achievement and were used as a measuring tool for changes in students' behavior after the learning process. The researcher chose a problem-based learning model with a culturally responsive teaching approach in Class X-4 with a particular class and student characteristics. The learning media was PowerPoint, while the research development format would be teaching modules, student worksheets, learning media, and test questions. Teaching modules were prepared using a problem-based learning model with a culturally responsive teaching approach. The students' worksheets contained a brief description of the data concentration measurement (mode) material as well as several problems that students discussed during learning. Meanwhile, the preparation of assessments took the form of test questions, which were given at the end of the lesson to determine student learning outcomes.

In addition, *develop* stage aims to modify the learning device prototype. In this research, the validity of the research instrument was tested by a mathematics education lecturer and a mathematics teacher at SMAN 3 Lumajang. Based on the results of the validity test, the teaching module was declared valid with a (V_a) value of 2.71, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid so that the teaching module could be implemented. Student worksheets were also declared valid with (V_a) value of 2.81, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid. Hence, it could be implemented. However, the student activity observation sheet was also declared valid with (V_a) value of 2.79, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid. Hence, it could be used for data collection. Finally, the test questions were also declared valid with a (V_a) value of 2.88, in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid; thus, it could be used for data collection. Based on previously established effectiveness criteria, the learning tools produced in this research were included in the excellent category. It was due to the fact that 86% of the students who took the exam in class achieved scores of over 70, with an average class score of around 83.97. Besides that, the learning tools outcomes were also stated to be practical because the observation results of student activities showed a percentage of 94%, indicating that the learning implementation in this research was excellently committed.

After going through the field trial stage, the final learning tools, consisting of teaching modules, student worksheets, student activity observation sheets, and test questions, have been successfully developed. Then, *disseminate* stage intended that the learning tools would be distributed through outreach to the MGMP Mathematics forum at SMAN 3 Lumajang. Hopefully, mathematics teachers who are members of the forum can implement these learning tools in mathematics learning based on the material being taught.

This research only discussed data concentration measurement material at the senior high school level. However, the results of the validation and learning device tests showed that the learning devices that had been created met the criteria of being valid, effective, and practical based on established standards. Hopefully, the research results can contribute to the development of more

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effective and relevant mathematics learning tools for students' cultures. They can increase teachers' and students' awareness of the importance of integrating local culture into mathematics learning at school. Similar research has also been carried out by Masruroh & Fathani (2024), where their research results revealed that the mathematics learning tools based on the ethnomathematics of the traditional house of the Osing Banyuwangi Tribe that had been created met the criteria of being valid, practical, and effective.

4. Conclusion

In short, this research concluded that:

1. The problem-based mathematics learning tool with a culturally responsive teaching approach that has been developed in this research was considered valid. The learning tools consisted of teaching modules, student worksheets, student activity observation sheets, and test questions.
2. The practicality and effectiveness of problem-based mathematics learning tools with a culturally responsive teaching approach that had been developed in this research were considered excellent. It can be seen in student learning outcomes and student activities during learning.

In this research, researchers provided several recommendations as follows:

1. The learning tools that have been created still need to be tested in other schools that have different conditions in order to produce quality learning tools.
2. The learning tools created in this research only discussed material measuring data concentration at the senior high school level. Hopefully, future research can develop more varied learning tools in terms of integrated material, learning models, and culture.

Author Contributions

The first author focused on collecting, processing, and analyzing the research data. The second author contributed to creating the scientific articles and managing the publication process.

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Declaration of Competing Interest

The authors declare that there are no conflicts of interest.

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