

Development of Guided Inquiry-Based Student Worksheets for Optimizing Mathematical Understanding Skills

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Abstract: The application of teacher-centered learning in one of the high schools in Mataram City resulted in low mathematical understanding skills in students. This is because teachers only use textbooks as learning tools and rarely use student worksheets. The purpose of this study was to develop valid and effective guided inquiry-based student worksheets. The type of research used is research and development using the 4D model which is carried out to the development stage. Data collection techniques used interview guidelines, learner response questionnaires, and mathematical understanding ability tests. The data analysis technique consisted of validity analysis and effectiveness analysis. The results of data analysis showed that the learner worksheet product developed obtained a score of 4.30 by 1 device expert validator with very valid criteria, then received a score of 4.71 by 1 material expert validator with very valid criteria and obtained a score of 4.44 by 1 learning expert validator with very valid criteria. Furthermore, the guided inquiry-based student worksheet is an effective learning tool because the percentage of classical completeness reached 77.78% and the percentage of student response scores was 83% with very good criteria. So, it can be concluded that the development of guided inquiry-based student worksheets is valid and effective for optimizing students' mathematical understanding skills.

Keywords: Learner Worksheet, Guided Inquiry, Mathematical Understanding Ability

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Introduction

Nowadays, the implementation of an independent curriculum has been implemented at various levels of education. The independent curriculum is a curriculum with diverse intracurricular learning where content is optimized so that learners have enough time to understand concepts and strengthen competencies. In creating more optimal learning, the learning process in students is prioritized. In line with Mulyasa (2021), explained that the independent curriculum prioritizes the learning process, among others, through problem-based learning, project-based learning and inquiry. In addition, this curriculum requires teachers to be creative and innovative. In line with Sylvia & Purwati (2021), said that teachers must be creative and

innovative in designing learning such as teaching tools in order to develop students' creativity both in the classroom and outside the classroom.

Observations have been carried out in class X, at one of the high schools in Mataram City. This observation activity focuses on the learning process that occurs in the classroom. It is known that mathematics teachers at school still apply teacher-centered learning. During teaching and learning activities, the teacher explains and applies the material with the help of a projector to students. Then, students record the material on the screen and at the end of the lesson the teacher gives assignments to do at home. So, the communication that occurs is only one-way, namely from the teacher alone and students only listen to the material delivered by the teacher. Thus, the teacher's

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dominance in learning is very large while students are the opposite.

In addition, an interview was conducted with one of the math teachers at the school. Information was obtained that student worksheets are still very rarely used and teachers only use textbooks as learning tools in the classroom. This has an impact on the low learning outcomes of students. It is known from the results of the midterm exam in class X mathematics that there are classes that have a percentage of classical completeness of 0% only with an average score of 32.9. Based on the low midterm exam results, it indicates that students' mathematical understanding is also low.

Mathematical understanding ability is one of the important cognitive aspects in learning mathematics. According to Lestari & Yudhanegara (2015), explained that mathematical understanding ability is the ability to absorb and understand mathematical ideas. Meanwhile, according to Skemp (1978), mathematical understanding is divided into two levels, namely instrumental understanding and relational understanding. One solution in overcoming low mathematical understanding ability is improvement in the learning process. Factors that can determine the success of the learning process are learning tools.

Learning tools that can be used in supporting the learning process are the use of tools in the form of student worksheets (Mardeni, Azmi, & Linda, 2021). According to Mudrikah et al. (2021), student worksheets is a learning resource in the form of task sheets that contain instructions and evaluations related to material in accordance with the specified basic competencies. Another opinion says that student worksheets is a student worksheet that is done independently or in groups that contains guidelines for learning activities (Fristadi, Bharata, & Noer, 2018). From the above statement, student worksheets are a learning tool in which there are learning activity guides, teaching materials and tasks that are done independently or in groups by students in accordance with learning objectives. In addition, a learning model that is appropriate and suitable for the characteristics of students is also needed so that their understanding ability can be optimized.

The inquiry learning model is learning that involves investigation and discovery activities by students through guidance from the teacher. The main target of inquiry learning activities is the maximum involvement of students in the process of learning activities, the direction of activities logically and systematically, and developing a confident attitude in students about what is found in the inquiry process. In the inquiry learning model there are several types of inquiry that are often used such as guided inquiry, free inquiry, and modified free inquiry. However, this

study uses the guided inquiry model because it is in accordance with the characteristics of students. According to Purwanto (2023), guided inquiry is an inquiry learning model in which the teacher provides guidance or instructions to students. In its implementation, most of the planning is made by the teacher and students do not formulate problems but the teacher provides broad enough.

In this study, the student worksheets will be developed according to the steps of the guided inquiry model. Guided inquiry model steps such as open, immerse, explore, identify, gather, create, share, and evaluate (Kuhlthau, Maniotes, & Caspari, 2012). According to Anita, Agustina, & Rahmawati (2022), stated that guided inquiry-based student worksheets is an excellent choice because it contains a guide to learning activities with guided inquiry learning syntax that emphasizes students to actively make their own discoveries. In addition, research conducted by Mudhakhir, Prayitno, Tyaningsih, & Arjudin (2023), that the development of guided inquiry-based student worksheets is effective and can improve students' mathematical understanding skills.

Based on the previous explanation, it is necessary to develop learning tools that can help teachers and students in carrying out the learning process properly. So that researchers are interested in conducting research entitled "Development of Guided Inquiry-Based Student Worksheets for Optimizing Mathematical Understanding Skills" with the aim of making learning tools that are valid and effective in optimizing students' mathematical understanding skills.

Method

The type of research used in this study is development research (Research and Development). In this research, the development model used is 4D (Define, Design, Development, Dissemination) which is carried out until the development stage only. This model is used to develop guided inquiry-based student worksheets products on exponent material. The following is Figure 1 of the 4D model development cycle.

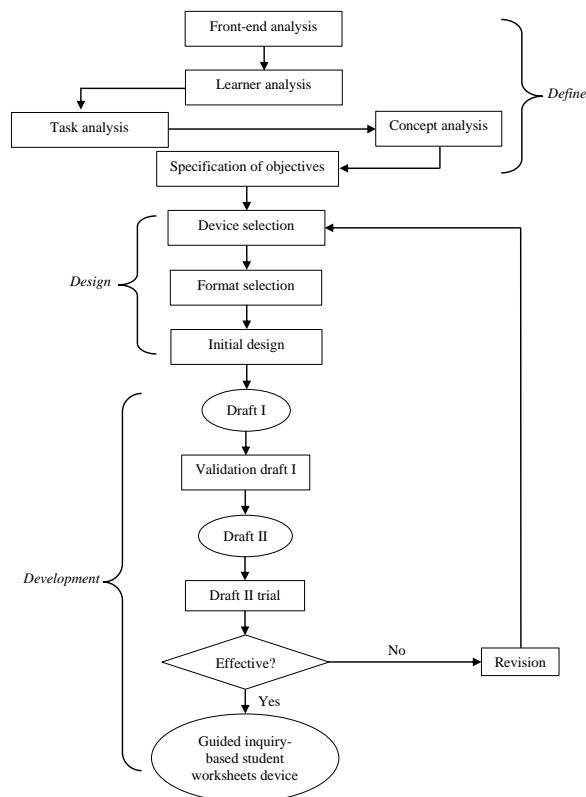


Figure 1. 4D Development Cycle

This research was conducted in the odd semester with the research subjects of class X.9 students as many as 36 people. The data collection techniques used are: interviews, questionnaires and test questions. The feasibility of guided inquiry-based student worksheets developed has several criteria that must be met, as follows.

a. The validity of student worksheets

The formula used to measure the score of the validity level of the guided inquiry-based student worksheets, namely:

$$X = \frac{\sum x}{n}$$

Description:

X = Validity score

$\sum x$ = Total score obtained

n = Number of statements

According to Turmuzi (2016), data obtained in quantitative form can be converted to qualitative data with reference to Table 1 below.

Table 1. Quantitative to Qualitative Data Conversion

Validity Index	Category
$X > X_i + 1,80 Sbi$	Highly Valid
$X_i + 0,60 Sbi < X \leq X_i + 1,80 Sbi$	Valid
$X_i - 0,60 Sbi < X \leq X_i + 0,60 Sbi$	Fairly Valid
$X_i - 1,80 Sbi < X \leq X_i - 0,60 Sbi$	Less Valid
$X \leq X_i - 1,80 Sbi$	Not Valid

Description:

Ideal average (X_i) : $\frac{1}{2}$ (ideal maximum score + ideal minimum score)

Ideal standard deviation (Sbi) : $\frac{1}{6}$ (ideal maximum score - ideal minimum score)

Based on the calculation results obtained, the score of the calculation results of the validity of student worksheets products according to expert validators is converted into qualitative criteria with the following reference guidelines Table 2.

Table 2. Criteria for validity of student worksheets

Validity Score	Criteria
$X > 4,21$	Highly Valid
$3,40 < X \leq 4,21$	Valid
$2,60 < X \leq 3,40$	Fairly Valid
$1,79 < X \leq 2,60$	Less Valid
$X \leq 1,79$	Not Valid

In this study, the guided inquiry-based student worksheets are said to meet the valid criteria if it obtains a validity value of > 3.40 based on the assessment results from device, material, and learning experts.

b. Effectiveness of student worksheets

Student worksheets based on guided inquiry is said to be effective based on test scores and student responses. The results of the test of students' understanding abilities are declared complete if the scores obtained meet the minimum completeness criteria set by the school in mathematics subjects, namely 75. The formula for determining the score for each student is as follows.

$$P_i = \frac{X_i}{X_{max}} \times 100$$

Description:

P_i = Score on a scale of 100

X_i = The final score obtained by each learner

X_{max} = Maximum score achieved (in this case = 32)

To find out the level of understanding ability of each student after conducting the test can be seen in Table 3 below.

Table 3. Criteria for Mathematical Comprehension Ability

Value	Criteria
$P_i < 55$	Very less
$55 \leq P_i < 60$	Less
$60 \leq P_i < 75$	Enough
$75 \leq P_i < 85$	Good
$85 \leq P_i \leq 100$	Very good

(Adapted : Agustini & Pujiastuti, 2020)

The learning tools developed are said to be effective if students reach the minimum completeness criteria classically (Lusyana & Lestari, 2022). The following formula is used to determine the percentage of classical completeness.

$$P = \frac{x}{n} \times 100\%$$

Description:

- P = Percentage of classical completeness
- x = Number of students who scored ≥ 75
- n = Many students take the test

In addition, students' responses are an indicator of the effectiveness of a learning design (Hindun, 2021). The following is the formula for measuring the effectiveness of the student worksheets device from the results of students' responses.

$$X = \frac{\sum x_i}{\sum x_{max}} \times 100\%$$

Description :

- X = Percentage of learner response scores
- $\sum x_i$ = Total number of scores obtained by each individual
- $\sum x_{max}$ = Total maximum score

The results of the calculation of the learner response questionnaire scores that have been obtained in the form of quantitative data are converted into qualitative criteria as in Table 4 below.

Table 4. Learner Response Category

Percentage	Criteria
$80\% < X \leq 100\%$	Very good
$60\% < X \leq 80\%$	Good
$40\% < X \leq 60\%$	Fairly Good
$20\% < X \leq 40\%$	Not Good
$X \leq 20\%$	Not Very Good

(Adapted: Irsalina and Dwiningsih, 2018)

Therefore, this guided inquiry-based student worksheets device is said to be effective if $\geq 75\%$ of students who take the test score above the minimum completeness criteria (≥ 75) and the percentage of students' response scores is $> 60\%$ with good criteria.

Result and Discussion

a. Results of development of student worksheets

In the define stage, the first step taken was a front-end analysis through classroom observations and interviews with mathematics teachers. From observations and interviews, information was obtained that mathematics learning is teacher-centered, the interaction that occurs is only one-way, teachers rarely use student worksheets and teachers more often use textbooks only. Furthermore, students were analyzed through teacher interviews and observations of student learning outcomes. It is known that the students' math skills are still low. Then, a task analysis is carried out which aims to identify the main tasks given to students in the form of student worksheets products. Furthermore, concept analysis is carried out, namely selecting general achievements and achievements per element according to the curriculum on exponent

material. Finally, formulating learning objectives, namely students can identify the properties of exponents, exponent functions and root forms.

At the design stage, the first step is the selection of devices. The device used is student worksheets because it is in accordance with the results of observations and interviews with teachers. Furthermore, format selection is carried out which aims to design learning content. The student worksheets device is arranged based on guided inquiry learning steps such as open, immerse, explore, identify, gather, create, share and evaluate. Finally, the initial design of the device is carried out, namely the design of all learning devices that will be tested.

At the development stage, the first step is design and product validation. During this step, the student worksheets will be assessed and given input by device experts, material experts and learning experts so that it is suitable for use. The device experts and material experts in this study consisted of one lecturer in the Mathematics Education study program at Mataram University while the learning expert was one mathematics teacher at school. Furthermore, revisions were made to the product according to the input from the experts and revalidated until the product was declared suitable for use.

The last step is limited field trials, testing products that have been declared valid by experts. In this study, the student worksheets device that has been declared valid is used in the learning process in class X.9 for three meetings. Then at the last meeting, students were given test questions and questionnaires to determine the effectiveness of the product in optimizing mathematical understanding skills. The following Table 5 suggests improvements and input from experts.

Table 5. Suggestions for Improvement by Experts

Expert	Suggested Improvements
Device	Lies in the numbering of each page, the sound of the question prompt in the gather step and fixing the conjunction in each sentence
Material	Located in the description of student worksheets and learning stages of guided inquiry-based student worksheets devices
Learn	Located on each cover of the guided inquiry-based student worksheets.

b. Results of Research Data Analysis

The analysis of the validity of student worksheets consists of three instruments, namely device expert instruments, material expert instruments and learning expert instruments. The validators of device experts and material experts consisted of one lecturer in the mathematics education study program at

FKIP, Mataram University. Meanwhile, learning experts from one math teacher at school. The following table shows the results of the validation of student worksheets by validators.

Table 6. Results of student worksheets Validation

Assessment	Validity Score	Criteria
Device	4,30	Very valid
Material	4,71	Very valid
Learning	4,44	Very valid

Analysis of the effectiveness of student worksheets, can be seen from the test scores that have been obtained and also the response of students. Tests and response questionnaires aim to determine the effectiveness of the products that have been developed which were attended by 36 students in class X.9. The following table shows the test results and responses of X.9 class students.

Table 7. Mathematical Comprehension Level

Level of Mathematical Understanding of Learners				
Very Less	Less	Enough	Good	Very Good
0	2	6	27	1

Table 8. Mathematical Comprehension Ability Test Results

Learners Complete	Learners Not Completed	Percentage of Classical Completion
28	8	77,78%

Table 9. Results of the Learner Response Questionnaire

Total Scores	Total Maximum Score	Percentage	Response Criteria
2244	2700	83%	Very Good

Based on Table 8 and Table 9, the guided inquiry-based student worksheets can be said to be effective for optimizing mathematical understanding skills because the test results with the percentage of classical completeness $\geq 75\%$ and also the percentage of learner response scores $> 60\%$.

a. Results of student worksheets based on guided inquiry

Student worksheets based on guided inquiry, consists of an initial page that contains a description and learning stages of student worksheets. These learning stages contain the interaction of the teaching and learning process between teachers and students according to the steps of guided inquiry. Furthermore, the guided inquiry-based student worksheets on

exponent material consists of three meetings of material such as the properties of exponents one meeting, exponent functions one meeting and root forms one meeting. The material presented in each meeting is adjusted to the guided inquiry learning steps, namely open, immerse, explore, identify, gather, create, share and evaluate.

The guided inquiry-based student worksheets developed by researchers is in line with research conducted by Mudhakhir et al. (2023), namely meeting valid criteria, effective in optimizing mathematical understanding skills and students have a very good response to student worksheets. However, research conducted by Fara, Noer, & Rasidin (2019), and Oktariyani, Roza, & Remiswal (2020), did not focus on students' mathematical understanding skills but communication and critical thinking skills. Furthermore, in the research conducted by Kamilia, Baidowi, & Hapipi (2021), it is known that there are no indicators of ability measured after using student worksheets products. student worksheets products developed in this study have advantages over products in previous studies, namely guided inquiry-based student worksheets products cover one learning outcome about exponents so that there are three meetings.

b. The validity of student worksheets based on guided inquiry

It is known that the guided inquiry-based student worksheets have been validated by expert validators. From the device experts obtained a validity score of 4.30 with very valid criteria, then from the material experts obtained a validity score of 4.71 with very valid criteria and from learning experts obtained a validity score of 4.44 with very valid criteria. From the results of this assessment, the guided inquiry-based student worksheets device developed is very valid for use in learning, this is in accordance with the validity score obtained from each validator.

In the research conducted by Sridana, Soepriyanto, Sarjana, & Amrullah (2018), it is known that the student worksheets device developed has met the validity with very valid criteria. Furthermore, research conducted by Ulantina, Sridana, Lu'luilmaknun, & Soepriyanto (2023), found that the student worksheets device has met the validity criteria with very valid criteria from material experts and device experts. In line with this research, the guided inquiry-based student worksheets device has met the validity with very valid criteria according to the device, material and learning experts.

c. Effectiveness of guided inquiry-based student worksheets

In this study, the guided inquiry-based student worksheets device on exponent material is said to be effective if $\geq 75\%$ of students who take the mathematical understanding ability test score above the minimum completeness criteria (≥ 75) and the percentage of student response scores is $> 60\%$ with good criteria. This is in line with Lusyana & Lestari (2022), that the learning tools developed are said to be effective if students reach the minimum completeness criteria classically. In addition, according to Hindun (2021), student response is one indicator of the effectiveness of a learning design.

The results of calculations and data analysis carried out to see the effectiveness of guided inquiry-based student worksheets. It is known that there are 36 students who take the test, of which 28 are complete and 8 others are not complete. After calculating the percentage of classical completeness, the result was 77.78% . Furthermore, analyzing the response questionnaire data from 36 students obtained a total response score of 2244 with a response score percentage reaching 83% in the class. Therefore, it can be concluded that the guided inquiry-based student worksheets on exponent material is effective for optimizing students' mathematical understanding skills.

In the research conducted by Mudhakir et al. (2023), It is known that guided inquiry-based student worksheets is effective for improving mathematical understanding skills as seen from the increase in the percentage of students' completeness from 6.7% to 73.08% after using student worksheets products. Then, research conducted by Leha, Marsitin, & Fayeldi (2019), found that guided inquiry-based student worksheets is effective for use as a teaching tool as seen from the percentage of test average completeness of 84% which reached the excellent category. In line with this research, the guided inquiry-based student worksheets device is effective for optimizing students' mathematical understanding skills seen from the results of the percentage of classical completeness reaching $77.78\% \geq 75\%$ and the percentage of student response scores reaching $83\% > 60\%$.

Conclusion

Based on the research results, data analysis and discussion, it can be concluded as follows.

a. This research process uses the 4D model development research which is carried out up to the development stage only. At the define stage, researchers identified problems that occurred in the learning process so that the devices

developed could overcome these problems. At the design stage, researchers selected a device, namely student worksheets, which was adapted to the guided inquiry model. At the development stage, guided inquiry-based student worksheets were produced which were valid according to device experts, material experts and learning experts. So that the guided inquiry-based student worksheets are declared valid and suitable for use.

b. The guided inquiry-based student worksheets are an effective tool for optimizing students' mathematical understanding skills, this can be seen from the research results that the percentage of classical completeness reached $77.78\% \geq 75\%$ and the percentage of student response scores reached $83\% > 60\%$ with very good criteria.

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