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The Effectiveness of STEM-PjBL-Based Mathematics Student Worksheets on the Cognitive Learning Outcomes of Grade V MI Students

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Abstract

This study aims to develop and test the feasibility and effectiveness of STEM-PjBL-based Student Worksheet (LKPD) in improving students' cognitive learning outcomes. The development of the LKPD was carried out using the ADDIE model, which consists of the stages of Analysis, Design, Development, Implementation, and Evaluation. The research method used is Research and Development (R&D). Validation was carried out by material experts, language experts, and graphic experts, and it was tested on fifth-grade students at MIN 05 Seluma to assess its effectiveness. The validation results showed that the developed LKPD is highly feasible according to material experts, language experts, graphic experts, and question item validation. The effectiveness test showed an improvement in students' learning outcomes with an average N-Gain score falling into the effective category. Thus, this STEM-based LKPD integrated with the PjBL model is declared valid, effective, and suitable for use as a Mathematics learning tool to improve students' cognitive learning. STEM-PjBL-based LKPD is recommended to be implemented in mathematics learning at the elementary madrasah level as an effort to improve the quality of learning and students' cognitive learning outcomes.

Keywords: LKPD; ADDIE Model; STEM; PjBL; Plane Figures.

Abstrak

Penelitian ini bertujuan untuk mengembangkan dan menguji kelayakan serta efektivitas Lembar Kerja Peserta Didik (LKPD) berbasis STEM-PjBL dalam meningkatkan hasil belajar kognitif siswa Pengembangan LKPD dilakukan model ADDIE yang terdiri dari tahapan Analysis, Design, Development, Implementation, dan Evaluation. Metode penelitian yang digunakan adalah Research and Development (R&D). Validasi dilakukan oleh ahli materi, ahli bahasa, dan ahli kegrafikan, serta diuji kepada siswa kelas V MIN 05 Seluma untuk menilai efektivitasnya. Hasil validasi menunjukkan bahwa LKPD yang dikembangkan memiliki tingkat kelayakan sangat valid dari ahli materi, ahli bahasa, ahli kegrafikan, dan validasi butir soal. Uji efektivitas menunjukkan peningkatan hasil belajar siswa dengan nilai rata-rata N-Gain yang masuk dalam kategori efektif. Dengan demikian, LKPD berbasis STEM terintegrasi model PjBL ini dinyatakan valid, efektif, dan layak digunakan sebagai perangkat pembelajaran Matematika untuk meningkatkan hasil belajar kognitif siswa. LKPD berbasis STEM-PjBL direkomendasikan untuk diterapkan dalam pembelajaran matematika

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di tingkat madrasah ibtidaiyah sebagai upaya meningkatkan kualitas pembelajaran dan hasil belajar kognitif siswa.
***Kata kunci**: LKPD; Model ADDIE; STEM; PjBL; Bangun Datar.*

INTRODUCTION

According to BSKAP Kemdikbudristek No. 46 of 2025, the Mathematics subject includes: (1) understanding Mathematics learning materials in the form of facts, concepts, principles, operations, and mathematical relations and applying them flexibly, accurately, efficiently, and appropriately in solving mathematical problems (mathematical understanding and mathematical skills), (2) solving problems which include the ability to understand problems, design mathematical models, solve the models, or interpret the solutions obtained (mathematical problem solving), and (3) relating Mathematics learning materials in the form of facts, concepts, principles, operations, and mathematical relations to a field of study, across disciplines, and to life (mathematical connections).

Winarni (2018:237) also explained that there are two factors that affect students' learning outcomes, namely internal factors and external factors. Internal factors are factors within the student, which include physiological factors such as physical condition and senses, interest, talent, intelligence, motivation, and cognitive abilities. Meanwhile, external factors are factors outside the students themselves, such as environmental factors, infrastructure, and administrative facilities.

Cognitive learning outcomes are learning outcomes related to memory, critical thinking, or intellectual ability. According to Anderson and Krathwohl (in Winarni, 2018:238), the cognitive domain includes two dimensions, namely cognitive processes and cognitive products. Cognitive processes consist of six aspects: remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6).

Next, an initial observation was carried out through interviews that had already been conducted by the researcher with the teacher. In classroom learning, the researcher found problems that arose in Mathematics learning activities, namely: (1) the teacher still implemented one-way teaching which resulted in students being less active in participating in learning activities, (2) the teacher only used the worksheets available in the students' textbook, and (3) the worksheets used were still difficult for students to understand, especially in Mathematics learning.

The results of the daily test scores for Mathematics learning in the first semester of the 2025/2026 academic year in Class V of MIN 3 Seluma are still low, as indicated by the average score of 62.67, which is below the Minimum Passing Criteria (KKTP) of 70. It is

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known that out of 15 students in Class V of MIN 3 Seluma, 10 students (67%) and 5 students (33%) achieved scores above the KKTP of 70. Therefore, to address this issue, it is necessary to develop learning tools, which can be in the form of Student Worksheets (LKPD) oriented towards the STEM-based integrated PjBL model in the Mathematics learning process.

PjBL (Project Based Learning) is a form of cooperative learning that directly involves students in producing specific projects from learning activities in order to address their own learning problems (Nababan et al, 2023). The PjBL learning model can provide students with real learning experiences, allowing them to think creatively and produce interesting products (Mokambu, 2022).

Based on the explanation above, it is necessary to develop Student Worksheet (LKPD) using an integrated STEM approach with the PjBL model in Mathematics subjects. The development of LKPD with an integrated STEM approach using the PjBL model has been widely conducted, but the researcher is carrying out a study that differs from previous research.

Therefore, the researcher conducted Research and Development with the title "Development of STEM-Based LKPD Integrated with the PjBL Model on the Material of Perimeter and Area of Flat Shapes to Improve Cognitive Learning Outcomes in Grade V MI Mathematics."

Based on the background of the problem, the objectives of this study are: first, to describe the characteristics of STEM-based Student Worksheets (LKPD) integrated with the PjBL model on the topic of Perimeter and Area of Plane Figures to improve cognitive learning outcomes in Mathematics for Grade V MI students. Second, to describe the feasibility of STEM-based Student Worksheets (LKPD) integrated with the PjBL model on the topic of Perimeter and Area of Plane Figures to improve cognitive learning outcomes in Mathematics for Grade V MI students in terms of their validity and reliability. Third, to describe the responses of teachers and students to the STEM-based Student Worksheets (LKPD) integrated with the PjBL model for improving cognitive learning outcomes in Mathematics for Grade V MI students. Fourth, to analyze the effectiveness of STEM-based Student Worksheets (LKPD) integrated with the PjBL model in improving cognitive learning outcomes in Mathematics for Grade V MI students.

RESEARCH METHOD

This research was conducted at MI Negeri 3 and MI Negeri 5 in Seluma Regency. The research was carried out during the odd semester of the 2025/2026 academic year. This study used a Research and Development (R&D) approach, aimed at developing a product (LKS)

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and testing its effectiveness in a learning context. According to Winarni (2018:248), Research and Development (R&D) or research and development is a series of steps or processes to refine a product or develop an existing product so that it can be accounted for.

The development model used in this study is the ADDIE Model. The ADDIE model is a term commonly used in everyday life to describe a systematic approach to development in learning. ADDIE is an acronym that refers to the main processes of developing a learning system, namely: analysis, design, development, implementation, and evaluation. The subjects of this study are divided into two groups: subjects for limited trials (implementation), which are fifth-grade students of MI Negeri 3 Seluma Regency, and subjects for effectiveness testing (evaluation), which are fifth-grade students of MI Negeri 5 Seluma Regency as the effectiveness test class. The object of the research is the development of STEM-based LKPD integrated with the PjBL model. It is in the subject area of Mathematics, specifically on the material of the perimeter and area of plane figures.

Qualitative data collection was carried out from the product validation stage in the form of criticisms, suggestions, and feedback from validators in improving STEM-based LKPD integrated with the PjBL model on the material of the perimeter and area of plane figures for 5th-grade students of MI Negeri 3, Seluma Regency. Meanwhile, quantitative data consisted of the assessment scores given by the validators, namely the level of validity, trial test scores, and effectiveness test scores.

At this stage of data collection techniques, the main objective is to obtain data. All data collection instruments used in this study are useful for identifying various deficiencies, advantages, criticisms, suggestions, and inputs regarding the research product prepared by the researcher. The data collection instruments are as follows: interviews, observations, questionnaires, and tests.

The instruments used in this study include test instruments to assess students' cognitive learning outcomes and non-test instruments consisting of interviews and questionnaires. Based on the research objectives, the designed instruments are: Preliminary Study Instrument, Expert Validation Instrument, Test Item Validation Instrument, Teacher Response Sheet, and Student Response Questionnaire (consisting of; Teacher Response Instrument, Student Response Questionnaire, test items, observation sheets).

The data analysis techniques used are, first, qualitative data analysis, which is needed to process the results of interviews on teacher needs and student need questionnaires, notes, suggestions, or comments found in the validation sheets provided by each expert validator, which can serve as a reference for improving STEM-based Mathematics student worksheets integrated with the PjBL model. Second, quantitative data analysis is used to describe the

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quality of the produced product, namely the STEM-based student worksheets integrated with the PjBL model, based on evaluations from material, language, and design experts, as well as to describe the learning outcomes of students after using the student worksheets during the learning process.

In the quantitative method, several stages are carried out, namely: Product Validation Assessment Analysis, Reliability, Teacher and Student Response Questionnaires, and Instrument Standardization. Next, the subsequent stage of instrument testing is conducted, which includes Validity Test, Reliability Test, Difficulty Level, Discrimination Power, and Effectiveness Analysis.

RESULTS AND DISCUSSION

This study uses the Research and Development (R&D) method with the ADDIE model. According to Winarni (2018: 263-265), the ADDIE model consists of five systematic stages, namely: (1) Analysis, which aims to identify problems and needs, (2) Design, which focuses on designing and planning the product, (3) Development, which includes the process of creating and developing the product, (4) Implementation, which is carried out by applying the product in the appropriate context, and (5) Evaluation, which aims to assess the effectiveness and efficiency of the product. This study develops STEM-PjBL-based Student Worksheet (LKPD) on the topic of Perimeter and Area of Flat Shapes for grade V MI. The research results are presented based on the stages of LKPD development that have been carried out in the following description:

1. Characteristics of STEM-PjBL-Based LKPD on Perimeter and Area of Plane Figures

This Mathematics LKPD, which was developed, is STEM-PjBL-based on the material of Perimeter and Area of Plane Figures to improve students' cognitive learning outcomes by carrying out several stages, namely:

1.1 Analysis Stage (analyze)

To describe the characteristics in this study, an analysis was conducted. The analysis consists of three stages: (a) curriculum analysis, (b) teacher and student needs analysis, and (c) LKPD analysis.

a. Curriculum Analysis

Curriculum analysis is carried out to ensure the suitability of the material with the competencies that must be achieved. The purpose of curriculum analysis is to identify Learning Outcomes (LO) as well as to map Learning Objectives (LOs) and the Learning Objective Framework (LOF) that correspond to the material on

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Perimeter and Area of Plane Figures in grade V. The development of this LKPD is done for the Mathematics subject in phase C, grade V, Academic Year 2025/2026.

b. Analysis of Teacher and Student Needs

The analysis of teacher and student needs is conducted to identify obstacles in learning as well as the most effective methods to improve students' cognitive learning outcomes. Then the researcher conducts a needs analysis. The needs analysis is carried out on the fifth-grade students and teachers of MIN 03 Seluma to identify the need for Student Worksheets (LKPD) on the topic of Perimeter and Area of Plane Figures in Mathematics that aligns with the characteristics of phase C students. The analysis stages involve two steps: first, the researcher interviews the fifth-grade teacher, then distributes a questionnaire to the fifth-grade students to determine the learning material needs at the school.

Based on the results of interviews with teachers and students regarding the needs analysis, it can be concluded that during the Mathematics learning process, the teacher only uses the LKPD available in the book, and the students' learning outcomes have not been fully achieved. The results from the dissemination of the questionnaire indicate that students enjoy learning by using LKPD and liking colorful LKPD.

c. LKPD Analysis

LKPD analysis is to analyze the LKPD that teachers have been using during the learning process in class.

1.2 Design Stage

The development of the Mathematics Student Worksheet (LKPD) is based on the results of document analysis and needs assessment through interviews, questionnaires, and observation of classroom implementation of the approach. The researcher determines the format of the Mathematics LKPD following the guidelines of the Ministry of Education and Culture Regulation of the Republic of Indonesia No. 22 of 2022.

The process of creating the Mathematics LKPD is carried out using the Canva for Education application. This is because Canva for Education is a platform that provides various attractive templates and elements, is easy to use, and is ready to use or modify according to needs.

In the development process, the researcher did not forget to incorporate a STEM-based PjBL syntax learning model through the following stages:

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1) determining the essential question, where students observe images and educational videos, followed by a Q&A session between students and the teacher to understand the concepts of perimeter and area of plane shapes (science and technology), 2) planning the project, where students are divided into several groups, then they observe the teacher's explanation regarding the tools and materials needed for the project, 3) scheduling the project creation and completion, where students, together with the teacher, make an agreement on the project creation schedule and the project completion deadline, 4) monitoring the progress of project completion, where students work in groups under the guidance of the teacher to work on the project and discuss their analysis during the project (engineering and mathematics), 5) presenting and testing the results, where the project completion involves representatives from each group taking turns to present their results. the project, and 6) evaluating and reflecting on the process and outcomes of the project, namely students, with the guidance of the teacher, reflecting on the project process and results.

The LKPD designed by the researcher was carried out through the following steps:

1.2.1 Initial Section

The first step in creating a Mathematics LKPD using the Canva application is to download the Canva application from the Playstore first. Figure 4.1 shows the Canva application that has been downloaded from the Playstore.

Image of downloading the Canva app on the Play Store

After downloading the app, the next step is to install the Canva app on the laptop. Then log in to Canva with your email and click the plus sign to create a design in the top left corner and select a document (A4 vertical). The design creation interface is shown in Figure 4.2 below:

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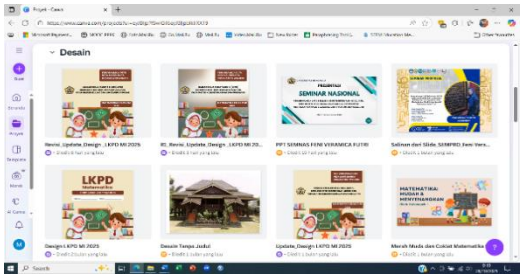

Image of Creating a New Design for the LKPD Front Cover

This menu presents various ready-to-use templates that are attractive and full color. However, the researcher preferred to design the cover independently without using the templates provided by Canva. This was done to better match the cover with the content that will be presented. The researcher only needs to select the elements to be used and add text descriptions in the menu. The text is on the left side of the Canva application. In the text menu, we can also adjust the position, font type, and font size used in the LKPD front cover design. The Mathematics LKPD front cover design created by the researcher is presented in Figure 4.3 below.

Front Cover Image of LKPD

After successfully creating the front cover, the researcher then added a foreword, table of contents, LKPD usage instructions, CP, and TP. The foreword was made by adding text to the text menu on the left, which was then adjusted for placement, position, font type, and font size according to writing standards. The font used is Times New Roman with a size of 12. The foreword title is centered, and the content of the foreword is justified.

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The table of contents was created by the researcher first using the Word application, then converting the file format to JPG. Next, the converted Word file into JPG was uploaded to the Canva app by clicking upload in the upload menu. The table of contents is then ready to be inserted into the Canva application. The creation of the table of contents was done at the final stage to ensure the correct pages so that no further changes would be needed.

Meanwhile, CP and TP were created directly on the Canva application. The creation of CP and TP aims to help users understand what will be the targets for using the Mathematics LKPD with the STEM-PjBL model. To make it more interesting for students to read the CP and TP, several elements related to the perimeter and area of flat shapes were added in the Canva application. The following are the CP and TP designs created by the researcher.

Design Images of CP and TP

1.2.2 Content/ Learning Activities

The steps of the learning activities are carried out in two meetings. The first meeting follows these steps:

1.2.2.1 Determining the Basic Questions

The Mathematics LKPD developed presents concepts in the form of images of traditional houses from Bengkulu province and video barcodes about the material on the perimeter and area of flat shapes. Then the teacher gives the opportunity to ask questions related to the images of traditional houses from Bengkulu province and the learning video about the concepts of perimeter and area of flat shapes.

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Syntax Image 1 Determining Basic Questions

1.2.2.2 Preparing Project Planning and Creating a Schedule In the second syntax,

The teacher divides the class into 5 groups of 4 students each. The teacher also explains the tools and materials needed for the project and explains the project that the students will work on in groups. Then, the students watch a tutorial video on making a model house from cardboard. In the third syntax, the teacher and students reach an agreement on the project creation schedule, and then the students create a project completion schedule while considering the predetermined deadlines.

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Figures of Syntax 2 and 3 Determining Planning and Preparing Project Schedules

For the second meeting, perform the syntax as follows:

1.2.2.3 Monitoring Students and Evaluating Project Results

In the fourth syntax, students, with guidance from the teacher, create a house model from cardboard. The teacher monitors students' activity during the project, tracks the progress realization, and provides guidance if difficulties arise. After that, students discuss issues encountered during project completion, and each group writes a report on the project they worked on. In the fifth syntax, representatives from each group take turns presenting their project results in front of the class. Then, the teacher gives rewards to the groups that have presented.

Figure Syntax 4 & 5 Monitoring Students and Testing Project Results

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1.2.2.4 Evaluating Experience

In the sixth syntax, students, with teacher guidance, reflect on the process and results of the project. The teacher and students engage in a question-and-answer session regarding the activities that have been carried out.

Syntax Image 6 Evaluating Experience

1.2.3 Closing Section

At this stage, the researcher compiles a bibliography containing reference sources used during the creation of the LKPD, which includes images and video links. The following bibliography design created by the researcher is presented in Figure 4.11.

Illustration of Creating a Bibliography

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2. Feasibility of STEM-PjBL-Based LKPD on Perimeter and Area of Plane Figures

2.1 Development Stage

To describe the feasibility in this study, a validation test was conducted. Validation was carried out by six validators, consisting of two material experts, two language experts, and two graphic/design experts. They assessed the content suitability, readability, and appearance of the LKPD using the prepared validation instruments. The validation results served as the basis for revisions to make the LKPD more optimal before becoming the final product ready to be used in Mathematics learning. The following are the validation results from each validator:

2.1.1 Material Aspect Validator

The material validation process is carried out by two validators. The results of the material experts' assessment of the STEM-PjBL-based worksheets on perimeter and area of flat shapes are presented in the following table:

Table of Recapitulation of Material Aspect Validation Results

No. Item	Penilaian Ahli		Kofisien Korelasi V	Interpretasi
	Rater 1	Rater 2		
1	4	4	1	Validitas Tinggi
2	4	4	1	Validitas Tinggi
3	4	3	0,83	Validitas Tinggi
Rata-rata			**0,94**	**Validitas Tinggi**

Based on the results of the material validation above, all items in the assessment instrument showed a high level of validity, with correlation coefficients ranging from 0.83 to 1. This indicates that the LKPD is considered feasible and of good quality according to both validators.

Then, a reliability test was conducted. The reliability test showed an agreement rate between the two raters of 67%, which falls into the category of strong agreement. This indicates that the assessment instrument has good consistency in evaluating the STEM-based integrated PjBL model LKPD on circumference and area of flat shapes. The results of the reliability test are presented in Table 4.4 as follows:

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Table of Reliability Test Results for Material Aspects

No. Aspek	Penilaian Ahli		Perbedaan Skor Rater 1 & 2
	Rater 1	Rater 2	
1	4	4	0
2	4	4	0
3	4	3	1
Jumlah Kesepakatan			**2**
Jumlah Variabel			**3**
Presentase Kesepakatan			**67%**
Level Kesepakatan			**Kuat**

In addition to providing assessments, subject matter expert validators also offer suggestions and comments to improve the quality of LKPD. The feedback includes adjusting images to spark curiosity and tailoring videos to the concepts of perimeter and area of flat shapes. These suggestions and comments serve as the basis for revisions to make LKPD more effective in supporting the Mathematics learning process.

Before Revision After Revision

Images Before and After the Material Aspect

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In the image above, the material expert validator also provided suggestions regarding the appearance of the Student Worksheet (LKPD). Initially, before the revision, the researcher included images of children who would be the subjects of the study and added a QR code scan for the learning video media. However, after discussing with the material validator, he suggested removing the image from the barcode so that only the barcode appears, making it easier to scan and improving the appearance.

2.1.2 Language Aspect Validator

Validation of the language aspect was carried out by two validators. The results of the language expert's assessment of the STEM-integrated PjBL model Student Worksheet on perimeter and area of flat shapes are presented in the following table:

Table of Recapitulation of Language Aspect Validation Results

No. Aspek	Penilaian Ahli		Koefisien Korelasi V	Interpretasi
	Rater 1	Rater 2		
1	4	4	1	Validitas Tinggi
2	4	4	1	Validitas Tinggi
3	4	4	1	Validitas Tinggi
4	4	3	0,83	Validitas Tinggi
Rata-rata			**0,96**	**Validitas Tinggi**

Based on the results of the linguistic expert validation above, all aspects of the assessment instrument show a high level of validity, with correlation coefficients ranging from 0.83 to 1. This indicates that the LKPD from the language aspect is considered feasible and of good quality according to both validators.

Next, a reliability test was conducted. Based on the language reliability table, the level of agreement between the two raters reached 75%, which falls into the strong agreement category. The results of the reliability test are presented in the following table:

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Table of Language Aspect Reliability Test Results

No. Aspek	Penilaian Ahli		Perbedaan Skor Rater 1 & 2
	Rater 1	Rater 2	
1	4	4	0
2	4	4	0
3	4	4	0
4	4	3	1
Kesepakatan			**3**
Variabel			**4**
Presentase Kesepakatan			**75%**
Level Kesepakatan			**Kuat**

In addition to providing evaluations, language expert validators also offer suggestions and comments. The feedback given includes adjustments to the spacing in the bibliography. The suggestions and comments from these language expert validators serve as a basis for improvements to make the LKPD more effective.

Before Revision After Revision

Images Before and After Revision in Language Aspect

In the images of the bibliography and closing templates, the language expert validator also provided suggestions and comments. In the first template, the bibliography writing did not indent, and after validation by the language

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validator, it was requested that the second paragraph be indented slightly in accordance with the standard bibliography writing rules. With this input, the researcher used it as a reference to revise the closing template, making the bibliography section slightly indented according to the rules of bibliography writing.

2.1.3 Graphical Aspect Validator

The validation of graphical aspects was conducted by two validators. The expert assessment results of the graphical aspects of the STEM-integrated PjBL model worksheets on perimeter and area of flat shapes are presented in the following table:

Recapitulation Table of Graphical Aspect Validation Results

No. Aspek	Penilaian Ahli		Koefisien Korelasi V	Interpretasi
	Rater 1	Rater 2		
1	4	3	0,83	Validitas Tinggi
2	4	4	1	Validitas Tinggi
Rata-rata			**0,92**	**Validitas Tinggi**

Based on the design experts' validity above, the calculation of Aiken's V validity coefficient yielded a value of 0.92, indicating a high level of validity. This suggests that the graphic aspects in the LKPD have been assessed as very good and in accordance with the established standards.

Next, a reliability test was conducted. Based on the reliability test results of the graphics, the level of agreement between the two raters reached 50%, which falls into the moderate agreement category. The results of the reliability test are presented in the following table:

Table of Reliability Test Results for Graphic Aspects

No. Aspek	Penilaian Ahli		Perbedaan Skor Rater 1 & 2
	Rater 1	Rater 2	
1	4	3	1
2	4	4	0
Kesepakatan			**1**
Variabel			**2**

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Presentase Kesepakatan	**50%**
Level Kesepakatan	**Sedang**

In addition to evaluating, graphic design expert validators also provide suggestions and comments, such as the need to apply bright colors to attract students. This feedback is used as a basis for improvements to make the LKPD more effective.

Before Revision After Revision

Images Before and After Revision of Graphic Aspects

In the image above, there are also revisions made by the researcher. At the beginning of creating the cover template, the researcher used a light cream color approaching pink. However, according to the graphic validator, this color seemed dull and too soft to be presented to students. Therefore, the graphic expert validator advised that a bright color should be applied to attract students' attention. According to the validator, the cover template should preferably be colored purplish blue so that the color appears more vibrant, bright, and slightly soft, making it visually appealing to students.

3. Teacher and Student Responses to the STEM-PjBL Based Math Worksheets on Perimeter and Area of Plane Figures

3.1 Implementation Stage

This stage involves the application of Math Worksheets using a STEM approach integrated with the PjBL model directly in classroom learning. This is carried out to determine the results of the instrument standardization test and the effectiveness of

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the Math Worksheets using a STEM approach integrated with the PjBL model on the topic of perimeter and area of plane figures in improving the cognitive learning outcomes of fifth-grade Madrasah Ibtidaiyah students.

User response testing for the development of worksheets using the STEM-PjBL approach includes:

a) Teacher's Response

The teacher's response was obtained through an interview with the fifth-grade teacher at MI Negeri 05 Seluma. Based on the interview, it was found that the material on the circumference and area of plane figures aligns with the STEM-PjBL steps. The appearance of the Mathematics Student Worksheet (LKPD) is attractive and facilitates teaching. The STEM-PjBL-based Mathematics LKPD design suits the students' characteristics, and the barcode display makes it easier to deliver the material. This Mathematics LKPD is suitable for STEM-PjBL-based learning with the topic of circumference and area of plane figures. The Mathematics LKPD is easy to understand during the teaching and learning process. Group activities are suitable for the concept of circumference and area of plane figures. This LKPD is appropriate as supplementary teaching material for learning Mathematics on the topic of circumference and area of plane figures and can enhance students' cognitive learning outcomes.

b) Student Response

The collection of student responses was carried out in Grade V at MIN 03 Seluma as a trial class to assess the effectiveness of the LKPD used in Mathematics learning. The sample used in this study consisted of 20 students from the total population. Student responses were collected through prepared instruments to obtain data on their experiences using the LKPD. Based on the aspect of appearance, the LKPD used received a very good rating with a percentage of 93.3% from 6 items with a total score of 112. In terms of content, the LKPD received a very good rating with a percentage of 100% from 1 item with a total score of 20, while in terms of benefits, the LKPD received a very good rating with a percentage of 100% from 1 item with a total score of 20. The results of the student response questionnaire are presented in the following table:

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Table of Student Response Questionnaire Results

No	Aspek yang Dinilai	Skor	Persentase	Kategori
1	Tampilan	112	93,3%	Sangat Baik
2	Materi	20	100%	Sangat Baik
3	Manfaat	20	100%	Sangat Baik

4. Effectiveness of LKPD on the Material of Perimeter and Area of Plane Figures Based on STEM-PjBL

4.1 Evaluation Stage (Evaluation)

To determine the effectiveness of this LKPD, a standard test of the test instrument and an N-gain test were conducted.

4.1.1 Standard Test of the Test Instrument

The essay questions to be used for the pretest and posttest were validated by two validators. From the data analysis obtained from the two validators, regarding the material aspect, the validity agreement data was 1.00, and it can be concluded that the material aspect used in the essay test instrument shows a very valid result. For the validation of the language aspect, the language validity expert agreement index reached 0.95, and it can be concluded that the language aspect used in the instrument questions shows a very valid result, while the construction agreement index reached 1.00, and it can be concluded that the construction aspect used in the essay test instrument shows a very valid result. After the essay question instrument was validated by the validator, the question instrument was tested in class V of MIN 3 Seluma with a total of 20 students. After obtaining the trial test scores, the data were processed to determine the validity of the test items, reliability, level of difficulty, and discriminative power.

4.1.1.1 Test of Question Item Validity

The results of the analysis of the question item validity are presented in the table

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Table of Question Item Validity Test Results

No. Butir Soal	Indikator Soal	Jenjang Kognitif	r_{hitung}	r_{tabel}	Kriteria
1	Penerapan	C3	0,831	0,444	Sangat Tinggi
2	Penerapan	C3	0, 776	0,444	Tinggi
3	Analisis	C4	0,860	0,444	Sangat Tinggi
4	Evaluasi	C5	0,709	0,444	Tinggi
5	Mencipta	C6	0, 860	0,444	Sangat Tinggi

The results of the question validity test above, based on the calculated r value ≥ the r table at a 5% significance level, indicate that all items are considered valid with validity values ranging from 0.709 to 0.860. This shows that each question item has a strong relationship with the measured indicators, both at the cognitive levels of application (C3), analysis (C4), evaluation (C5), and creation (C6). Therefore, this question instrument is suitable for measuring students' abilities according to the established cognitive levels.

4.1.1.2 Reliability Test

The reliability of the test items was measured using the Cronbach's Alpha formula, which resulted in a value of 0.731. Based on the reliability coefficient (r), this value falls into the high category and is considered reliable.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.731	.715	6

4.1.1.3 Item Discrimination Test

The results of the item discrimination level calculation are presented in the following table:

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Table of Item Discrimination Test Results

No. Butir Soal	Indikator Soal	Jenjang Kognitif	Daya Beda	Kategori
1	Penerapan	C3	0.492	Baik
2	Penerapan	C3	0.502	Baik
3	Analisis	C4	0.786	Sangat Baik
4	Evaluasi	C5	0.608	Baik
5	Mencipta	C6	0.786	Sangat Baik

Based on the results of the item discrimination test above, all the test items have good to very good discrimination power, with a value range between 0.492 and 0.786. Two of the items are classified as very good, indicating that these questions are capable of effectively distinguishing students with different levels of understanding. Meanwhile, the other three items fall into the good category, which means they can still be used to measure differences in students' abilities effectively. Thus, overall, the tested instrument has adequate quality in differentiating students' abilities.

4.1.1.4 Test of Question Difficulty Level

The results of the question difficulty level test are presented in the following table:

Table of Question Difficulty Level Test Results

No. Butir Soal	Indikator Soal	Jenjang Kognitif	Tingkat Kesukaran	Kategori
1	Penerapan	C3	0,637	Sedang
2	Penerapan	C3	0,612	Sedang
3	Analisis	C4	0,603	Sedang
4	Evaluasi	C5	0,687	Sedang
5	Mencipta	C6	0,600	Sedang

Based on the results of the difficulty level test of the questions above, it was concluded that all items fall into the "Medium" category with difficulty values ranging from 0.600 to 0.687. This indicates that

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the tested questions are neither too difficult nor too easy, so they can be effectively used to measure students' abilities well. Thus, the tested question instrument has a good balance in terms of difficulty level and can optimally support the learning evaluation process.

4.1.2 N-Gain Test

The N-Gain test in this development study of LKPD aims to measure the effectiveness of increasing students' understanding before and after using LKPD. By calculating the N-Gain, it can be determined to what extent LKPD contributes to the improvement of cognitive learning outcomes. In addition, this analysis helps evaluate the quality of the developed LKPD, so that conclusions regarding the effectiveness of LKPD can be more accurate and reliable.

The results of the N-Gain test show that the use of LKPD is effective in improving students' understanding. This is indicated by the average N-Gain value in the effectiveness class of 78.48%, which falls into the high category. Thus, it can be concluded that the developed LKPD is able to contribute significantly to the improvement of students' cognitive learning outcomes.

B. Discussion

1. Characteristics of LKPD on the Topic of Perimeter and Area of Plane Figures Based on STEM-PjBL

The structure of this LKPD refers to the latest guidelines relevant to the Merdeka Curriculum, namely the 2025 Learning and Assessment Guide published by the Agency for Standards, Curriculum, and Educational Assessment (BSKAP). This guide provides principles, strategies, and evaluation for learning as well as assessments.

To ensure that the LKPD aligns with the expected competency standards, its preparation is also based on the Learning Outcomes (CP) listed in BSKAP No. 046 of 2025 concerning Learning Outcomes.

The development of this Student Worksheet (LKPD) is based on an integrated STEM approach with the PjBL model syntax, which emphasizes active student involvement in the learning process. STEM-PjBL is an approach that integrates four disciplines, namely science, technology, engineering, and mathematics, using six PjBL syntax steps. This aligns with the research by Kurniawati & Dayu (2022) stating that STEM-PjBL-based student worksheets are more effective compared to the regular

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student worksheets used by elementary school teachers. According to Dalifa et al. (2023), this STEM approach aims to help students collect, analyze, and solve the problems they face, while also understanding the interconnections between various issues in the context of their lives, through a comprehensive learning process. The implementation of STEM elements can, among other things, be presented in the form of a Student Worksheet (LKPD) that must meet feasibility/appropriateness tests in order to be used as intended. According to Widyastuti (2022:20), the PjBL syntax model can be presented in several stages, including: starting the learning by determining a basic question, planning the project, arranging the schedule, monitoring the activities and project progress, and having students evaluate the project being carried out. The developed LKPD structure includes the introduction section, the main content section, and the closing section of the text.

This LKPD is designed with complete components suitable for supporting the success of learning. Based on the Regulation of the Ministry of Education and Culture of the Republic of Indonesia No. 22 of 2022, the LKPD format contains the essential elements of LKPD, including: 1) the beginning section (cover page, foreword, table of contents, LKPD usage instructions, and CP and TP) 2) the content section (learning activities following the PjBL syntax), and 3) the closing section (bibliography). This LKPD format will help students understand the learning objectives, participate in activities effectively, and evaluate their understanding of the material.

The developed LKPD has met the criteria of a good LKPD as stated by Kosasih (2023). There are four main criteria in LKPD development, namely: LKPD structure (which includes title, learning instructions, supporting information, tasks and working steps, as well as assessment), content, language, and LKPD appearance. This LKPD covers all these components. In terms of content, the material is arranged according to the Learning Outcomes and is designed to enhance understanding as well as encourage active student participation. The language used is communicative, appropriate to the developmental level of the students, and easy to understand. Meanwhile, the LKPD appearance is designed to be attractive, systematic, and informative, which can increase learning interest and make it easier for students to understand the material.

2. Feasibility of STEM-PjBL-Based Student Worksheets on Perimeter and Area of Plane Figures

These STEM-PjBL-based student worksheets on perimeter and area of plane figures have been validated through three stages, namely material validation, language

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validation, and design validation. The validation aims to refine the developed worksheets to meet the feasibility standards in learning. Through the validation process, the aspects of material, language, and graphics are systematically evaluated to ensure that the worksheets can be used effectively and meet the needs of the students. Thus, the results of this validation can improve the quality of the worksheets and support a more optimal learning process.

Material validation is carried out to ensure that the content of the LKPD aligns with the Mathematics curriculum standards and the predetermined Learning Outcomes (LO). In addition, this validation also considers the developmental stage of the students, particularly phase C students who are at the concrete operational stage. Thus, the material presented in the LKPD is arranged to be easily understood, relevant to the students' real-life experiences, and capable of supporting their thinking processes in accordance with the cognitive characteristics at this stage of development. The validation agreement index by material experts reached 0.94, which falls under the category of "very valid," with a reliability coefficient percentage of 67%, indicating a "strong" level of agreement.

After going through the material validation stage, language validation was conducted. Language validation aims to ensure that the language used in the LKPD (Student Worksheet) complies with proper linguistic rules and is easily understood by students. This validation also aims to avoid ambiguity, grammatical errors, and the use of inappropriate terms so that instructions and material can be conveyed clearly. In addition, language validation ensures that the LKPD uses language appropriate to the students' cognitive development level, particularly in phase C, in order to support their understanding and engagement in learning optimally. The results of the linguist's validation of the LKPD show an agreement index of 0.96, which is categorized as “very valid,” and a reliability coefficient of 75%, which is considered “strong.”

After going through the stages of material and language validation, the next step is graphic validation, which aims to ensure that the Student Worksheet (LKPD) has an attractive appearance. This process involves assessing aspects such as layout and font usage. Graphic validation also aims to ensure that the LKPD supports the effective delivery of learning materials. Additionally, this validation intends to determine whether the LKPD design is suitable for the characteristics of the students, thereby enhancing their motivation and interest in learning. The results of the graphic expert validation on the LKPD showed an agreement index of 0.92, categorized as 'very valid,' with a reliability coefficient of 50%, which is considered 'moderate'.

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This LKPD has met the eligibility criteria of the National Education Standards Agency (BSNP), which include four main aspects: content eligibility, language, presentation, and graphics. In terms of content, the material is already in accordance with the Learning Outcomes, has clear activity objectives, and presents facts, theories, and concepts. The language aspect is fulfilled through the use of communicative language, proper sentence structures, and standardized terms and correct spelling. In terms of presentation, the LKPD is arranged in a coherent and systematic manner. The graphics aspect is fulfilled with an attractive appearance.

Based on the validation results and criteria from BSNP, this LKPD overall meets the standards for content eligibility, language, presentation, and graphics. In terms of content, the material presented aligns with the Learning Outcomes, has clear objectives, and presents facts, theories, and concepts. In terms of language, this LKPD uses communicative language, correct sentence structures, and systematically arranged terms and spelling. Additionally, the graphics aspect is also fulfilled with an attractive layout that supports student understanding. With all indicators met, this LKPD is considered suitable as effective teaching material according to BSNP standards.

The results of this LKPD validation are in line with the findings of Wulandari et al. (2024), who concluded that the development of the STEAM-based PjBL LKPD model is highly valid and feasible to use in learning. Based on expert evaluations, the material aspect scored 97.72%, the language aspect 93.75%, and the graphic aspect 93.75%, as well as responses from teachers and students at 91.29%. Thus, both previous research results and this validation emphasize the importance of developing structured LKPDs that are tailored to students' needs to maximize their understanding and engagement in the learning process.

3. Teacher and Student Responses to the STEM-PjBL-Based Worksheet on Perimeter and Area of Plane Figures

The teacher's response test was conducted using interviews, and the student's response test was conducted using questionnaires. Teacher response data were obtained through interviews with the fifth-grade teacher at MIN 05 Seluma. Based on the conducted interviews, it can be concluded that the material on perimeter and area of plane figures aligns with the steps of STEM integrated with the PjBL model. The appearance of the Mathematics worksheet is attractive and facilitates teaching. The STEM-PjBL integrated Mathematics worksheet design matches student characteristics, and the barcode display simplifies the delivery of the material. This Mathematics

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worksheet is suitable for STEM-PjBL integration with the material on perimeter and area of plane figures. This Mathematics LKPD is easy to understand during the teaching and learning process. Group activities are suitable for the concept of perimeter and area of plane figures. This LKPD is suitable as additional learning material for Mathematics on the topic of perimeter and area of plane figures and can improve students' cognitive learning outcomes.

The student response test was conducted in Grade V at MI Negeri 03 Seluma on a STEM-based LKPD integrated with the PjBL model. Among other things, students liked the attractive design and colors, enjoyed discussion activities, and it could improve learning outcomes. In line with this, Prastowo (2023) stated that this learning material contains elements that are simpler compared to a module. The LKPD consists of six main elements, which include: 1) the title, which is the name used for the book or chapter in the book that summarizes the material, 2) study instructions, which are steps in the learning process, 3) Learning Outcomes or core material, which are the abilities gained from knowledge and attitudes, 4) supporting information, which is the material presented, 5) assignments, which are used to assess the students' knowledge, and 6) assessment, which provides an overview of students' understanding towards learning materials. Meanwhile, research conducted by Andaresta & Rachmadani (2021) found that this STEM approach can train science literacy skills to complete projects carried out together.

4. Effectiveness of Developing STEM-PjBL-Based LKPD on Perimeter and Area of Plane Figures

The effectiveness of developing STEM-based LKPD integrated with the PjBL model is seen in the conceptual aspect. The implementation of this LKPD can also guide students to relate project activities to everyday life, such as the project of making a simple house model from cardboard carried out by the students. This is in line with research conducted by Yulaikah et al. (2023), which stated that the STEM approach is considered effective in improving elementary students' understanding of science concepts.

The sample in this study consisted of 20 fifth-grade students from MIN 05 Seluma. The initial stage of the research involved conducting a pretest before any interventions were given. Subsequently, learning was carried out using STEM-PjBL-based student worksheets on the topic of the perimeter and area of flat shapes.

The analysis of the pretest and posttest in the fifth grade showed a significant

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improvement. There was a difference in the average scores between the pretest and posttest. Based on these results, the pretest yielded an average score of 41.88%, whereas the average score obtained from the posttest was 85.63%. The N-Gain test based on the students' completed tests resulted in a mean of 0.7848 with a percentage of 78.48%, which falls into the "high" category and can be considered effective. Therefore STEM-based LKPD integrated with the PjBL model on the material of perimeter and area of plane figures is effective in improving the cognitive learning outcomes of fifth-grade MI students. This is in line with research conducted by R Fauziah et al. (2024), which states that the implementation of a STEM approach integrated into learning activities is designed to increase students' active engagement and critical thinking skills through contextual projects relevant to daily life. Meanwhile, research conducted by Kurniawati and Dayu (2022) found that STEM-PjBL-based student worksheets are more effective compared to the standard student worksheets commonly used by elementary school teachers.

In the context of the implementation of this learning, the approach used is STEM, and the PjBL learning model is applied. The learning activities were carried out in two meetings. The first meeting involved learning activities through a syntax consisting of:

a) Determining Fundamental Questions

Students begin by observing images and video presentations about the traditional houses of Bengkulu province. Then the teacher provides fundamental questions about the video. This syntax is related to elements of science and technology, because students are given questions and watch videos related to learning Mathematics on the material of perimeter and area of flat shapes.

Documentation Images of Syntax 1 Implementation

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b) Planning The Project

The formation of groups can be based on the characteristics or diversity of students. The groups were divided into 5, each consisting of 4 people. Students listened to the teacher's explanation about the tools and materials for making the project. Students listened to the teacher's explanation regarding the projects that the students would work on in groups. Students watched a tutorial video on making a cardboard model house (technology element).

Documentation Image of Sintak 2 Implementation

c) Preparing the Project Creation and Completion Schedule

Teachers and students make agreements on the project creation schedule. After that, students prepare a project completion schedule while considering the deadlines that have been set.

Documentation Images of Syntax 3 Implementation

In the second meeting, learning activities were conducted through syntax consisting of:

1) Monitoring the Progress of Project Completion

Students, with teacher guidance, create a model house from cardboard (engineering). The teacher monitors students' activity during the project,

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observes the progress, and provides guidance if they encounter difficulties. Students discuss issues that arise during the project completion with the teacher (mathematics). Each group writes a report on the project they have worked on in the prepared student worksheets (LKPD).

Documentation Images of the Implementation of Sintak 4

2) Presenting and Testing Project Results

Representatives of each group take turns presenting their project results in front of the class. Other groups observe and give feedback. The teacher and students give rewards to the group that has presented.

Kelompok 1

Kelompok 2

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Kelompok 3

Kelompok 4

Kelompok 5

Documentation Image of the Implementation of Syntax 5

3) Evaluating and Reflecting on the Process and Results of the Project

Students, with guidance from the teacher, reflect on the process and results of the project. The teacher and students engage in a question-and-answer session about the activities that have been carried out.

Documentation Image of Syntax 6 Implementation

Evaluation not only focuses on learning outcomes but also on the learning process experienced by students. In the integrated STEM approach using the PjBL model, evaluation is conducted comprehensively to measure

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students' cognitive, affective, and collaborative skills achievements. Consistent with the research conducted by Ambarwati et al. (2025), it is stated that the effective implementation of the PjBL model can improve students' Mathematics learning outcomes and encourage active student engagement in the learning process. Meanwhile, according to Sari & Kurniawan (2022), project-based and self-reflection evaluation can enhance students' metacognition regarding their strengths and weaknesses during learning. Furthermore, research conducted by Sutaphan & Yuenyong (2023) clarifies that projects carried out by students can improve learning outcomes integrated into STEM learning in schools.

CONCLUSION

The implementation of STEM-PJBL based Mathematics Student Worksheets (LKPD) shows that project-based learning with the integration of the four STEM dimensions can enhance student engagement and cognitive learning outcomes in madrasah students. This STEM-PJBL based LKPD can assist teachers in daily mathematics instruction and facilitate students in solving mathematical problems. The STEM-PJBL based LKPD includes Learning Achievements, learning objectives, and six PJBL syntax steps that greatly aid students in learning, understanding the material, and generating creative ideas in solving mathematical problems. Based on research results, it is expected that fifth-grade teachers in madrasahs can use this LKPD as an alternative in classroom mathematics learning, thereby helping to improve students' reasoning and numeracy skills. It is recommended that other researchers develop mathematics learning modules based on the CTL (Contextual Teaching and Learning) and STEM learning model theories.

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