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## PROJECT BASED LEARNING (PjBL) - BASED STUDENT WORKSHEETS ON INTEGRAL CALCULUS TO FASILITATE STUDENT'S PROBLEM SOLVING

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### Abstract

Integral Calculus instruction often faces challenges in developing 21<sup>st</sup> century skills, particularly in problem-solving. Initial observations indicate that students struggle to apply integral concepts to real-world contexts, largely due to passive, non-interactive conventional teaching methods. This phenomenon leads to low student engagement and inadequate problem-solving abilities. Therefore, this study aimed to develop a Project Based Learning (PjBL)-based student worksheet proven to be valid, practical, and effective as a solution to enhance students' problem-solving skills. This research used the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation). Data were collected through expert validation, student response questionnaires, and N-gain analysis from pre- and post-test results. The findings show that the developed worksheets are highly valid (average 4.5), practical (average student responses above 4.20), and effective (average N-gain 0.71), indicating a significant improvement in students' problem-solving skills. In conclusion, the PjBL-based worksheets successfully serve as a valid, practical, and effective innovation for addressing these learning problems. It is recommended that future research conduct trials on a broader scale to enhance the generalizability of the findings and develop more comprehensive instruments to measure soft skills holistically.

**Keywords:** ADDIE, Integral calculus, Problem solving, Project based learning, Student worksheet.

### Abstrak

Pembelajaran Kalkulus Integral seringkali menghadapi tantangan dalam mengembangkan keterampilan abad ke-21, khususnya dalam pemecahan masalah. Observasi awal menunjukkan bahwa mahasiswa kesulitan menerapkan konsep integral ke konteks nyata, yang sebagian besar disebabkan oleh metode pembelajaran konvensional yang pasif dan kurang interaktif. Fenomena ini mengakibatkan rendahnya keterlibatan mahasiswa dan kemampuan pemecahan masalah yang kurang memadai. Oleh karena itu, penelitian ini bertujuan untuk mengembangkan sebuah Lembar Kerja Mahasiswa (LKM) berbasis Project Based Learning (PjBL) yang terbukti valid, praktis, dan efektif sebagai solusi untuk meningkatkan keterampilan pemecahan masalah mahasiswa. Penelitian ini menggunakan model pengembangan ADDIE (Analysis, Design, Development, Implementation, and Evaluation). Data dikumpulkan melalui validasi ahli, kuesioner respons mahasiswa, serta analisis N-gain dari hasil tes awal dan akhir. Hasil penelitian menunjukkan bahwa LKM yang dikembangkan sangat valid (rata-rata 4.5), praktis (rata-rata respons mahasiswa di atas 4.20), dan efektif (rata-rata N-gain 0.71), menunjukkan adanya peningkatan signifikan pada keterampilan pemecahan masalah mahasiswa. Kesimpulannya, LKM berbasis PjBL berhasil menjadi inovasi yang valid, praktis, dan efektif dalam mengatasi permasalahan pembelajaran tersebut. Disarankan agar penelitian selanjutnya melakukan uji coba dalam skala yang lebih luas untuk meningkatkan generalisasi temuan dan mengembangkan instrumen yang lebih komprehensif untuk mengukur soft skill secara holistik.

**Kata kunci:** ADDIE, Kalkulus integral, Pemecahan masalah, Project based learning, Lembar Kerja Mahasiswa.



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## INTRODUCTION

Contemporary higher education necessitates the cultivation of critical thinking, collaboration, and problem solving skills among students (Ashari et al., 2025; Wang & Abdullah, 2024). The expectation is that students will not only comprehend theoretical concepts but also be able to effectively apply their knowledge in real-life situations, including solving problems relevant to their future professions (Antao & Morales, 2025). Consequently, there is an evident need for innovative and interactive learning approaches to bridge the gap between theory and practice.

Based on initial observations, interviews, and surveys conducted with research subjects in the Integral Calculus course at IAIN Lhokseumawe, students were found to have difficulty understanding both definite and indefinite integral concepts. They also struggled to apply these integral concepts to real-world contexts (Aji & Khan, 2019; Monariska, 2019). The conventional teaching methods, which are often theoretical and less engaging, resulted in students being less involved in their learning. This lack of engagement led to weak problem-solving skills, as students weren't provided with learning experiences that encouraged independent and creative analysis of problems (Cahyaningsih et al., 2021). This phenomenon highlights the urgent need to integrate an active learning approach like Project-Based Learning (PjBL) to address the challenges of 21<sup>st</sup> century education.

PjBL is a proven effective teaching model, but its application in Integral Calculus is limited. There are also few studies on developing PjBL-based teaching materials, especially those focused on improving problem-solving skills (Fadli et al., 2024).

Furthermore, the implementation of PjBL in this study was restricted to a single class, so the findings cannot be generalized to a broader student population. Soft skills such as collaboration and communication were also not measured in depth and implementation faced time and resource constraints (Hazim et al., 2024). This highlights a gap that future research should address by more deeply developing and measuring the application of PjBL in calculus instruction. Therefore, this study aimed to develop a valid, practical, and effective Project Based Learning (PjBL)-based student worksheet for the Integral Calculus course

While Project Based Learning has been empirically proven to be effective in enhancing cognitive and affective skills across various disciplines (Almulla, 2020; Asmara et al., 2025; Berhиту et al., 2020), its application in Integral Calculus remains minimal. Research on the development of PjBL-based teaching materials for calculus, particularly those focused on improving problem-solving skills, is still rare (Susanti et al., 2023). This study addresses this gap by developing PjBL-based student worksheets specifically designed for the Integral Calculus course. These materials focus on applying integral concepts in contextual projects to enhance real-world problem-solving, such as calculating area and volume (Setyawan & Astuti, 2021; Surtini et al., 2023).

The primary objective of this study is to develop valid, practical, and effective Project Based Learning (PjBL)-based student worksheets to facilitate students' problem-solving skills in Integral Calculus. These worksheets are designed to provide an interactive and applicative learning experience, with the goal of deepening

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students' understanding of integral concepts and significantly enhancing their problem-solving skills. Ultimately, this study aims to contribute by offering innovative and structured teaching materials as an alternative to conventional methods, thereby improving the quality of calculus instruction and better preparing students for future professional challenges.

## **METHODS**

The product development process employed the ADDIE model (analysis, design, development, implementation, and evaluation) to ensure a systematic and quantifiable approach (Rahmandhani & Utami, 2022). The research procedure systematically followed the ADDIE model stages: Analysis involved identifying student needs and problem-solving difficulties through interviews and surveys. The Design phase focused on developing the PjBL-based student worksheets and evaluation instruments based on the analysis findings.

The development of the PjBL (Project Based Learning)-based student worksheets involved creating a prototype and having it validated by experts. The implementation stage was carried out by applying the validated worksheets in class to collect data on students' problem-solving skills. Finally, evaluation was conducted both formatively for product refinement and summatively to measure the product's effectiveness in enhancing students' problem-solving skills. Operationally, the summative evaluation stage included administering a pre-test and a post-test to measure improvement, analyzing the quantitative data using N-gain analysis, distributing questionnaires to students to measure their responses and the practicality of the

worksheets, and conducting observations and interviews to obtain qualitative data on their effectiveness.

The instruments used in this study include: (1) Student Needs Questionnaire: This questionnaire is used at the analysis stage to understand the needs of students in learning Integral Calculus and the abilities that still need to be developed, (2) Validation Sheet: Used by material experts and learning experts to assess the content validity and design of PjBL worksheets. The aspects assessed include the suitability of the material, readability, and relevance of the PjBL context, (3) The Test of Problem Solving Skills is an assessment instrument specifically designed to measure students' proficiency in problem comprehension, solution planning, execution, and verification. This test was administered as both a pre-test and a post-test in conjunction with the use of the Project Based Learning (PjBL) worksheets to evaluate the impact of PjBL on students' problem-solving skills, and (4) Response questionnaire: Used to collect qualitative data regarding student involvement and responses to PjBL-based learning, in which responses are categorized into four levels: strongly agree (SS), agree (S), disagree (TS), and strongly disagree (STS).

This research employs two primary instruments: a material expert validation sheet for evaluating the instructional content, and a student response questionnaire designed to gather feedback regarding the utilization of the project based learning student worksheets during lectures. The validity of the Project Based Learning (PjBL) student worksheets is assessed using the material expert validation sheet, while the student response questionnaire is used to determine their practicality. Indicators for material expert validation

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include: suitability for learning objectives, clarity of instructions, relevance of content, completeness of material, readability and visual design, the intervention demonstrates potential to enhance students' problem-solving skills and usability. The material expert validation instrument consists of 20 (twenty) Likert-scale statement items. Meanwhile, the student response questionnaire is designed to gather responses regarding the use of the Project Based Learning-based student worksheets in integral calculus courses. This student response questionnaire instrument consists of 10 (ten) statements.

Descriptive qualitative analysis provides an overview of the reliability and usefulness of the instructional resources utilized by students during lectures (Yanuarni et al., 2021). The development phase of this study culminated in project based learning student worksheets that successfully demonstrated reliable, useful, and efficient standards. student worksheets are considered valid, practical and effective if they meet the criteria of the score range (Sr), which is shown in Table 1.

Table 1. Valid, Practical and Effective Criteria (Setyawan & Astuti, 2021)

Interval	Validity level		
	Validity	Practical	Effective
$Sr > 4,2$	Very Valid	Very Practical	Highly Effective
$3,4 \leq Sr \leq 4,2$	Valid	Practical	Effective
$2,6 \leq Sr \leq 3,4$	Fairly Valid	Practical enough	Effective Enough
$1,8 \leq Sr \leq 2,6$	Less Valid	Less Practical	Less Effective
$Sr \leq 1,8$	Invalid	Not Practical	Ineffective

In addition, the data collected was qualitative descriptive data. As triangulation, source triangulation was used. The data analysis utilized a five-point Likert scale, with scores categorized into specific intervals for interpretation. The scoring intervals are categorized as follows: scores from 1.00 to 1.80 indicate Very Poor performance, 1.81 to 2.60 denote Poor, 2.61 to 3.40 are considered Fair, 3.41 to 4.20 represent Good, and 4.21 to 5.00 signify Very Good. This categorization framework facilitates the interpretation of results, providing a clear basis for concluding the level of respondent acceptance toward the investigated technology.

To scientifically establish theories or design principles, the systematic reflection and documentation of the

developed Project Based Learning-based student worksheets validity and practicality become the main focus of the research.

To assess the efficacy of the learning materials, data analysis involved calculating the percentage gain in learning outcomes by contrasting students' pretest and posttest scores. This calculation utilized the formula developed by Riduwan (Linda & Sugandi, 2021), as presented in Formula (1):

$$E = \frac{f}{N} \times 100\% \quad (1)$$

Where:

E: Effectiveness of the percentage of responses

F: Obtained score

N: Maximum score

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Effectiveness was measured using the normalized gain method. The normalized gain was calculated and analyzed using the formula by Meltzer (2002), as presented in Formula (2). The N Gain criteria according to Hake (Meltzer, 2002) are outlined in Table 2.

$$N \text{ Gain} = \frac{\text{Score Posttest} - \text{Score Pretest}}{\text{Score Maximal} - \text{Score Posttest}} \quad (2)$$

Table 2. N Gain Value Categories

N Gain Score	Category
$N \text{ Gain} < 0,30$	Low
$0,30 \leq N \text{ Gain} \leq 0,70$	Medium
$N \text{ Gain} > 0,70$	High

Based on the Table 2, learning is considered effective if problem solving skills achieve an N Gain score of  $\geq 0.3$ , falling into the medium or high criteria.

## RESULTS AND DISCUSSION

This study utilizes the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) development model to create Project Based Learning (PjBL) - based student worksheets for Integral Calculus courses. The research stages and their results are described as follows:

### 1. Analysis

The analysis stage identified student needs and challenges in understanding integral concepts and problem-solving skills through interviews, questionnaires, and observations. The findings indicated that students experienced difficulties in comprehending definite and indefinite integral concepts and their real-life applications. Furthermore, conventional learning methods, which tend to be theoretical, frequently resulted in suboptimal student engagement. Therefore, PjBL-based teaching materials were identified as a potential solution to enhance problem-solving skills through contextual and applicative approaches.

### 2. Design

The design of the PjBL-based student worksheets was structured based on the findings from the analysis stage, with the primary objective of improving students' problem solving skills. The student worksheets content includes real-world case studies, structured problem-solving step guides, and collaborative tasks. The design also incorporates assessment rubrics, pre-test and post-test instruments, and student engagement questionnaires.

Visualizations, such as diagrams and graphs, were integrated to facilitate concept comprehension. ensure they can navigate each project stage independently. This visual presentation, along with the content of the instructions, is vital for the practicality of the student worksheets, enabling students to understand expectations and the necessary steps for successful project completion.

The visual presentation of the PjBL-based student worksheet is provided in Figure 1.

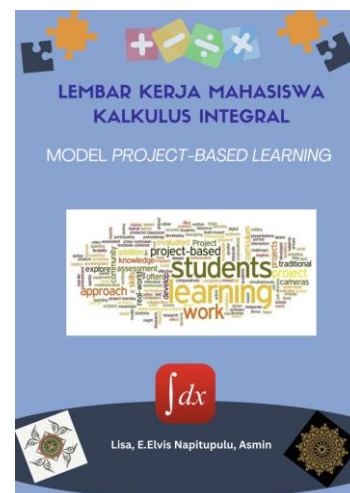


Figure 1 Student worksheet cover illustration

Figure 1 presents the illustration of the Project-Based Learning (PjBL)-based student worksheet's front cover. This visual representation serves as a

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concrete output of the research and development process, providing tangible evidence of the developed product. As the initial visual element, the student worksheet's cover plays a crucial role in establishing the identity of the instructional material and implicitly communicating the subject (Integral Calculus) and the pedagogical approach (PjBL) to students. Its inclusion is essential for adhering to the reporting standards of development research, directly showcasing the research's deliverable to the reader.

Subsequently, Figure 2 illustrates the project objectives and instructions for completing the student worksheet.

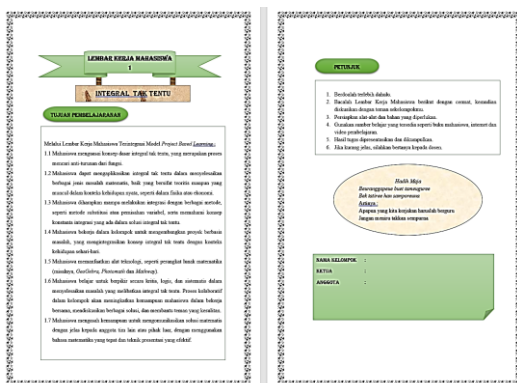


Figure 2 Project Objectives and Student Worksheet Instructions

Figure 2 illustrates the project objectives and instructions for completing the student worksheet. This section is crucial in PjBL-based student worksheets as it directly guides students through the learning process. Clear project objectives provide direction and context for students on what they need to achieve, while detailed instructions.

Figure 3 presents the essential questions, the project planning design (including tools, materials, and steps), and the schedule as follows.

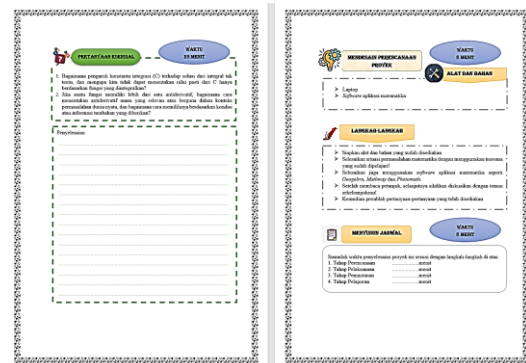


Figure 3. Display of Essential Questions and Project Planning Design (including tools, materials, and steps)

Figure 3 displays the essential questions, project planning design (including tools, materials, and steps), and schedule compilation within the student worksheet. This section is vital in PjBL as it directly guides students through the planning phase. Essential questions spark critical thinking, the planning guide aids task organization, and schedule compilation teaches time management, collectively supporting the overall practicality and effectiveness of the student worksheet.

### 3. Development.

Prototypes of the PjBL-based student worksheets were developed and evaluated by material experts and instructional design experts. Validation results demonstrated that the prototypes met the criteria for content validity, relevance, and readability. The trials were conducted with a limited number of student participants, yielding results that indicated increased student engagement and their ability to complete integral concept-based projects. The feedback received during these trials was utilized to refine the student worksheets.

To evaluate the quality and feasibility of the developed Project-Based Learning (PjBL)-based Student

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Worksheets, a validation process by three experts was conducted. Table 3 presents their comprehensive assess-

ment results across various aspects of the student worksheet's.

**Table 3. Validation Results of Student Worksheet Development Based on Project Based Learning**

No.	Assessment Aspect	Validator 1	Validator 2	Validator 3	Average Score	Description
1.	Appropriateness to Learning Objectives	4.5	4.7	4.6	4.6	Very Valid
2.	Clarity of Instruction	4.3	4.5	4.4	4.4	Valid
3.	Content Relevance	4.6	4.8	4.7	4.7	Very Valid
4.	Completeness of Material	4.4	4.5	4.5	4.5	Valid
5.	Readability and Visual Design	4.2	4.3	4.4	4.3	Valid
6.	Potential to Improve Problem Solving Skills	4.6	4.7	4.7	4.7	Very Valid
7.	Ease of Use by Students	4.4	4.6	4.5	4.5	Valid

Based on the analysis of validation results (Table 3), the student worksheets demonstrate a high degree of alignment with the designed learning objectives, particularly in the development of problem-solving skills. The instructions within the student worksheets are deemed clear, though a suggestion was made to include initial problem-solving step examples to further facilitate student comprehension. The student worksheets content is also highly relevant to Integral Calculus material, especially in the application of integrals to contextual problems.

While the material presented is sufficiently comprehensive, validators recommended adding more varied case studies. From a design perspective, the student worksheets visual appearance is considered good but requires further improvement, such as increasing font size and adding color to emphasize important information. Overall, this student worksheets exhibits excellent potential to enhance students' ability to identify, analyze, and solve problems. Furthermore, it is deemed easy for students to use, though feedback was received to simplify certain steps for greater practicality.

**Table 4. The Development of Project-Based Learning - Based Student Worksheets Yields Practical Outcomes**

No.	Assessment Aspect	Validator 1	Validator 2	Validator 3	Average Score	Description
1.	Ease of Understanding by Students	4.5	4.6	4.5	4.5	Very Practical
2.	Appropriateness of Implementation Time	4.4	4.5	4.3	4.4	Very Practical
3.	Completeness of Instruction	4.3	4.5	4.4	4.4	Very Practical
4.	Ease of Access by Lecturers and Students	4.6	4.7	4.6	4.6	Very Practical
5.	Suitability to Project Based Activities	4.5	4.7	4.6	4.6	Very Practical
6.	Flexibility in Application	4.4	4.5	4.4	4.4	Very Practical

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Based on the analysis of practicality results (Table 4), the student worksheets demonstrate a high level of ease of understanding by students, supported by clear instructions and project flows for each section. The time allotted for completing tasks within the student worksheets is deemed quite appropriate, although validators suggested flexibility in implementation duration, especially for slower groups.

The instructions in the student worksheets are also considered sufficiently complete, yet there was feedback to include more in-depth explanations at the initial stages for

students less accustomed to project based learning. This student worksheets is highly accessible and usable by both lecturers and students, in both digital and print formats. Designed effectively to support project based activities, the student worksheets significantly facilitate collaborative work and the application of key concepts to practical issues within group settings. Furthermore, the student worksheets is quite flexible for implementation across various learning contexts, whether individually or in groups, with minor suggestions for adaptation in large classes.

Table 5. Results of the effectiveness of the development of student worksheets based on project based learning

No.	Assessment Aspect	Validator 1	Validator 2	Validator 3	Average Score	Description
1.	Achievement of Learning Objectives	4.6	4.7	4.5	4.6	Highly Effective
2.	Relevance to Student Needs	4.5	4.6	4.5	4.5	Highly Effective
3.	Support for Problem Solving	4.7	4.8	4.6	4.7	Highly Effective
4.	Linkage to Real Projects	4.6	4.7	4.6	4.6	Highly Effective
5.	Improved Student Collaboration	4.5	4.5	4.4	4.5	Highly Effective
6.	Development of Problem Solving Skills	4.6	4.7	4.5	4.6	Highly Effective
7.	Students' ability to complete the project	4.5	4.6	4.5	4.5	Highly Effective

Based on the analysis of effectiveness results (Table 5), the student worksheets demonstrate a high capability in supporting the achievement of learning objectives, such as understanding integral concepts and developing students' problem-solving skills. The student worksheets is also deemed highly relevant to student needs, particularly in overcoming difficulties in comprehending integral concepts and their application to real-world problems.

The student worksheets effectively facilitates students in identifying, analyzing, and solving problems through a project based approach. Its design effectively connects integral concepts with real-world situations, including applications in economics, physics, or engineering. Furthermore, the student worksheets promotes effective group collaboration, though some validators suggested strengthening guidelines for student

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interaction. It proves highly effective in fostering critical thinking among students, through both reflective questions and the analysis of provided projects. Ultimately, the student worksheets is also considered very effective in assisting students to complete integral-based projects with anticipated outcomes.

Numerous studies corroborate these findings. Project Based Learning (PjBL) significantly enhances critical thinking and problem solving skills when compared to traditional learning approaches (Adeline, 2024). Additionally, these outcomes align with the findings of Rehman et al. (2024), who assert that Project Based Learning (PjBL) facilitates a deeper comprehension of concepts due to students' active participation in resolving authentic problems. A meta-analysis conducted by Himmi et al. (2025) concluded that Project Based Learning (PjBL) demonstrably outperformed conventional techniques in enhancing problem-solving skills. Additionally, Syaripah

(2025) indicate that the validity and practicality of project based instructional materials are heavily influenced by their relevance and applicability to students' real-world contexts.

#### 4. Implementation

The validated student worksheets were implemented in an Integral Calculus class. Students work in groups to complete projects that include the application of integral concepts in real-world contexts, such as calculating the volume of a rotating object or modelling economic change. During the implementation, the lecturer acts as a facilitator. Data from observations, questionnaires, and tests showed that the student worksheets successfully increased student engagement and strengthened their problem-solving skills.

The Table 6 presents the results of 35 student responses regarding the development of Project Based Learning (PjBL) - based student worksheets in the Integral Calculus course.

Tabel 6. The outcomes represent student perceptions concerning the development of project based learning student worksheets

No.	Statement	Average Score
1	The worksheets helped me understand the integral concept better.	4.29
2	The projects given in the worksheets are relevant to real-life applications of integral concepts.	4.29
3	The worksheets motivate me to learn independently and be active in problem solving.	4.20
4	The guidance in the worksheet helped me complete each step in the problem solving.	4.31
5	The worksheets are visually appealing and easy to understand.	4.34
6	I feel more confident in doing integral calculus assignments after using the worksheet.	4.23

Table 6 presents the results of the analysis regarding student perceptions of the developed Project Based Learning (PjBL) - based student worksheets, where all items showed an average score above 4.20, indicating a

high level of satisfaction. Specifically, students reported a better understanding of integral concepts after using the student worksheets, with an average score of 4.29. This finding aligns with Markula & Aksela's (2022) research,

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which states that project based learning facilitates deeper understanding by directly involving students in real-world problem solving.

Perceptions regarding the relevance of projects to real-life applications of integral concepts were also highly positive (average 4.29). This corroborates Miller & Krajcik's (2019) view emphasizing how PjBL strengthens the connection between theory and practice, providing a contextualized learning experience. Furthermore, the student worksheets proved capable of motivating students towards active and independent learning in problem solving (average 4.20), consistent with Zen, Reflianto, Syamsuar, & Ariani (2022) findings that PjBL increases active student engagement by offering greater room for exploration and responsibility in the learning process.

The ease of use of the student worksheets was also reflected in an average score of 4.31 for the helpfulness of the guidance in problem-solving, and 4.34 for the visual quality and ease of understanding of the student

worksheets design. This aligns with Wati et al.'s (2024) research indicating that the validity and practicality of instructional materials are significantly influenced by systematic structure and appealing appearance. Lastly, students felt more confident in completing integral calculus assignments after using the student worksheets (average 4.23), indicating a positive impact on their self-efficacy. Overall, these results affirm that this PjBL-based student worksheets is well-received by students and effective in supporting the Integral Calculus learning process.

### 5. Evaluation

Evaluation was conducted both formatively and summatively. Formative evaluation during the development and implementation phases ensured that the student worksheets effectively met student needs. Summative evaluation, carried out via pre-test and post-test, yielded N Gain results analyzed using IBM SPSS Statistics 23. The descriptive statistics for N Gain are presented in the Table 7.

Table 7. Deskriptive Statistics N Gain

	N	Minimum	Maximum	Mean	Std. Deviasi
N_Gain	35	-61	.83	.7089	.05962
Persentase_N_Gain	35	61.29	83.33	70.8927	5.9607
Valid N (listwise)	35				

Based on Table 7, the average N Gain was 0.7089 (approximately 0.71), and the average N Gain percentage was 70.8927% (approximately 70.90%). This falls into the effective category, The N Gain analysis results, categorized as high, demonstrate a significant improvement in students' problem-solving skills.

Based on the research findings, a key discovery is that the development of Project Based Learning (PjBL)-based

student worksheets successfully created instructional materials proven to be highly valid, practical, and effective. This success was a direct result of the LKM's systematic and structured design. Specifically, the worksheets were crafted to bridge the gap between theory and practice—a critical issue in Integral Calculus instruction. By integrating real-world case studies and clear problem-solving guides, the LKM facilitated a significant improvement in

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students' problem-solving skills. This achievement was confirmed by a high N-gain score of 0.71, indicating a substantial enhancement.

These findings align with various previous studies that confirm the effectiveness of PjBL. Our results are consistent with the report by Adeline (2024), which found that PjBL significantly boosts critical thinking and problem-solving skills. Additionally, our findings are consistent with research by Rehman et al. (2024), which emphasizes that PjBL facilitates deeper conceptual understanding through active student participation.

While this study offers an innovative solution, certain limitations must be acknowledged. The trial implementation was confined to a single class group, which restricts the generalizability of the findings to a broader student population. Furthermore, although the LKM was designed to foster collaboration, these soft skills were not measured in sufficient depth. Thus, this research contributes by providing effective and structured instructional materials for improving Integral Calculus learning. The implications are clear: future studies should aim for a broader scale and develop more comprehensive instruments to holistically measure the benefits of soft skills.

## **CONCLUSIONS AND SUGGESTIONS**

Project-Based Learning (PjBL)-based student worksheet for Integral Calculus that is proven to be highly valid, practical, and effective. The worksheet serves as an innovative solution to address the primary challenges in Integral Calculus instruction, namely students' low ability to apply integral concepts to real-world contexts due to passive, conventional teaching methods.

Using the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation), the resulting worksheet demonstrated high quality. Its validity was confirmed by expert evaluations, which stated that the worksheet is highly relevant to learning objectives and has great potential to improve students' problem-solving skills. From a practicality standpoint, the LKM received a very positive response from students. They found the worksheet easy to understand and use, and it successfully motivated them to learn independently and actively.

Furthermore, the effectiveness of the PjBL worksheet was empirically proven. The N-gain analysis showed a significant improvement in students' problem-solving skills after using the worksheet. This finding is consistent with previous research indicating that project-based learning effectively enhances critical thinking and deep conceptual understanding. As a result, this PjBL worksheet successfully bridges the gap between theory and practice, preparing students to meet future professional challenges.

While this study makes a significant contribution, there are some limitations that can be the focus of future studies. The trial of this worksheet was limited to a single class, so the generalizability of the findings needs to be improved by conducting trials on a broader student population. Additionally, although this LKM was designed to encourage collaboration, the measurement of these soft skills was not in-depth. Therefore, it is recommended to develop more comprehensive instruments to holistically assess the impact of this LKM on non-academic abilities, such as collaboration and critical thinking.

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