

Integrating E-Module with Project Based Learning (PjBL): a Strategy to Improve Students' Collaboration Abilities and Scientific Literacy

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Abstract: This study explores the integration of E-Modules with Project-Based Learning (PjBL) as a strategy to enhance student collaboration and scientific literacy. The research follows the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) model and was conducted in one of the high schools in Central Java, involving limited trials and extensive trials (5 and 31) students. The developed E-Module was validated by experts, achieving an average score of 3.50 in both material and media evaluation, categorizing it as valid. The practicality assessment of the E-Module obtained 84.47% with a very practical category. Observations of collaboration skills yielded an 80.5% practicality score. The module's effectiveness was evident in the significant improvement of students' collaboration skills (N-Gain = 0.8, high category) and scientific literacy (N-Gain = 0.74, high category). These findings highlight the potential of PjBL-based E-Modules as an effective tool for improving student engagement, collaboration, and scientific literacy in measurement-related learning. The results suggest that this approach can be replicated or expanded to other topics to further enhance student-centered learning.

Keywords: Collaboration; E-module; Project Based Learning; Science Literacy

Introduction

Education plays a crucial role in shaping students' competencies in the 21st century, where collaboration and scientific literacy have become essential skills for success (Ağaoğlu & Demir, 2020; Kim et al., 2019). Collaboration skills are a combination of interpersonal intelligence and intrapersonal intelligence possessed by students. In line with the statement above, Junita & Wardani (2020) found that collaboration skills are skills that encourage students to actively contribute to cooperation and interaction in learning activities. While scientific literacy is the ability to understand, inform and implement science in the process of solving a problem (Daniah, 2020). Scientific literacy is the ability to understand science including knowledge, skills and

attitudes in creating critical thinking and contributing to solving scientific issues (Sutrisna, 2021).

In recent years, educators and policymakers have emphasized the need to integrate innovative teaching strategies to enhance these skills. However, many students still struggle with these skills due to the limitations of traditional teaching methods, which often focus on rote memorization rather than interactive and inquiry-based learning (Tawfik et al., 2020). This issue is particularly prevalent in science education, where students need to engage in hands-on and project-based activities to develop a deeper understanding of scientific concepts (Haatainen & Aksela, 2021). Therefore, there is a growing need to implement innovative teaching approaches that foster collaboration and scientific literacy among students.

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Despite the increasing emphasis on active learning strategies, many schools still rely on traditional teacher-centered approaches, which fail to provide students with meaningful learning experiences (Fatmaryanti et al., 2024). As a result, students often find science concepts difficult to grasp, and their ability to collaborate effectively with peers remains underdeveloped (Khoiri et al., 2021). Additionally, the rapid advancement of digital technology has not been fully utilized in the classroom to enhance learning outcomes. The challenge is how to integrate technology-based learning resources to improve student collaboration and scientific literacy.

Project-Based Learning (PjBL) has emerged as an effective pedagogical approach to foster active learning, critical thinking, and problem-solving skills (Eswaran, 2024). PjBL emphasizes student-centered inquiry, where learners engage in real-world projects that require collaboration and application of knowledge. Studies have demonstrated that PjBL enhances students' engagement and retention of scientific concepts compared to traditional lecture-based approaches (Hafeez, 2021; Mutanga, 2024). However, successful implementation of PjBL requires structured learning materials that support both student autonomy and teacher facilitation. Without appropriate resources, students may struggle to navigate projects effectively, and teachers may find it challenging to guide learning efficiently (Fatmaryanti et al., 2024).

To address these challenges, digital learning resources such as E-Modules have been increasingly utilized in education. E-Modules offer interactive and multimedia-rich content that can enhance student engagement and understanding of scientific concepts (Anggita et al., 2023). Furthermore, E-Modules can provide structured support for PjBL by offering structured instructions, simulations, and assessments that guide students through project-based tasks. Previous research has shown that digital learning tools can improve conceptual comprehension and motivation in science education (Lin & Chen, 2017; Meileni et al., 2021). However, the integration of E-Modules within PjBL frameworks remains underexplored, particularly in the context of improving both collaboration skills and scientific literacy simultaneously.

Existing studies on PjBL and E-Modules have primarily focused on their individual benefits rather than their combined potential. Research on PjBL has demonstrated its effectiveness in fostering problem-solving skills and engagement (Karan & Brown, 2022), while studies on E-Modules have highlighted their ability to support self-paced learning and content mastery (Syed Abd Latif et al., 2024). However, there is limited empirical research examining how the

integration of E-Modules within PjBL can synergistically enhance both student collaboration and scientific literacy. Moreover, most studies have focused on higher education settings, leaving a gap in understanding their application at the high school level (Herlina & Abidin, 2024; Holisoh et al., 2025).

This study aims to bridge these gaps by exploring how the integration of E-Modules with PjBL can improve student collaboration skills and scientific literacy. Unlike previous research that examines these strategies in isolation, this study investigates their combined impact, providing insights into how digital learning resources can effectively support project-based instructional approaches. The novelty of this research lies in its focus on designing an E-Module-enhanced PjBL framework that not only facilitates scientific understanding but also develop essential teamwork skills in a structured and interactive manner.

Method

The study adopts the ADDIE (Analysis, Design, Development, Implementation, Evaluation) instructional design model (Branch, 2010) to develop and assess the effectiveness of an E-Module-integrated PjBL approach. The research is conducted in a high school setting with 31 students, involving a structured implementation of E-Modules within PjBL activities. Key aspects examined include the validity and practicality of the developed E-Modules, student engagement, improvements in collaboration skills, and scientific literacy gains. The steps of ADDIE model in this study as seen in Figure 1.

At the analysis stage, learning needs analysis, curriculum analysis, media development analysis are carried out. At the Design stage, the e-module is designed by preparing measurement materials, compiling a needs map, and initial design. The development stage is by compiling instruments, expert validation, revision I and limited trials. The implementation stage is carried out with extensive trials, revision II. and the evaluation stage is the evaluation of the application of the e-module that has been developed.

Product validation from material experts is seen through aspects of material content, PjBL aspects, language aspects. Media expert validation is seen from aspects of appearance, presentation aspects, and readability aspects. Student response sheets are viewed from the aspects of appearance, presentation, and readability in Table. Collaboration ability instruments are viewed from the aspects of cooperation, responsibility, communication, group discussion, and flexibility. Science literacy ability instruments are

viewed from the aspects of context, knowledge of science, and competence.

The student response instrument for the appearance aspect contains: attractive cover, cover design according to the material, attractive layout, selection of layout and selection of attractive colors. The presentation aspect indicator contains: tables/videos/images according to the material, clear table/video/image descriptions, simulations according to the material, the material is easy to understand. The readability aspect indicator contains: easy-to-read fonts and sizes, and clear tables/videos/images.

developed and to determine the increase in students' collaboration and scientific literacy abilities with the application of the project based learning model. Data on students' collaboration and scientific literacy abilities were obtained from the collaboration ability questionnaire sheet and the student's scientific literacy test. The instrument for students' scientific literacy skills is shown in Table 1.

Table 1. Instrument for students' scientific literacy skills

| Dimension | Indicator |
|----------------------|--|
| Context | Current and recent personal, local, and global issues |
| Knowledge of science | Content knowledge (knowledge related to the occurrence of natural phenomena or science and technology and their impact on life) |
| | Procedural knowledge (knowledge related to scientific concepts and ideas discovered) |
| | Epistemic knowledge (knowledge related to the reasons underlying scientific discovery procedures and the truth of scientific concepts and ideas) |
| Competence | Ability to explain scientific phenomena |
| | Ability to evaluate and design scientific discoveries |
| | Ability to interpret data and evidence scientifically |

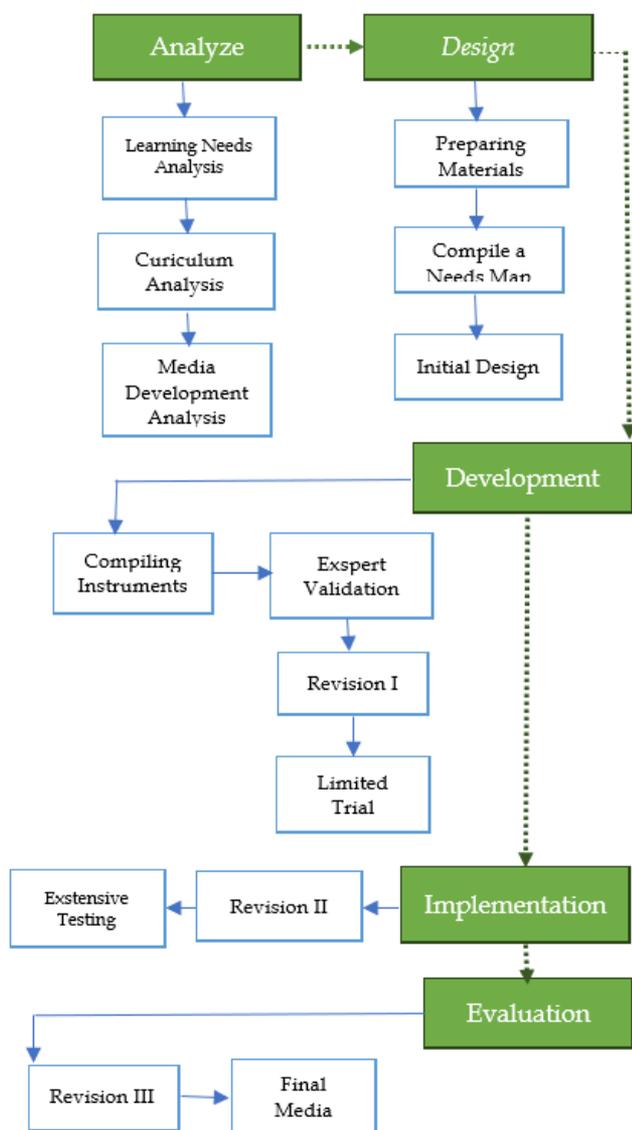


Figure 1. Research Cycle Diagram

The research instruments were in the form of product validation sheets, student response sheets, and trial instruments for students' collaboration and scientific literacy abilities. The research instrument aims to measure the feasibility of the product being

Table 2. Validity Analysis

| Interval Score | Percentage | Category |
|----------------|------------|--------------|
| 0.00-1.69 | 0% - 25% | Invalid |
| 1.70-2.59 | 26% - 50% | Less valid |
| 2.60-3.49 | 51% - 75% | Enough Valid |
| 3.50-4.00 | 76% - 100% | Very Valid |

Table 3. Practicality Analysis

| Percentage % | Criteria |
|--------------|----------------|
| 82 - 100 | Very Practical |
| 63 - 81 | Practical |
| 40 - 62 | Less Practical |
| 25 - 43 | Impractical |

To test the level of significance of the increase in students' collaboration and scientific literacy abilities, a two-sample test was carried out through a t-test with the help of SPSS. First, a normality test and a data homogeneity test were carried out

Table 4. Criteria N-Gain

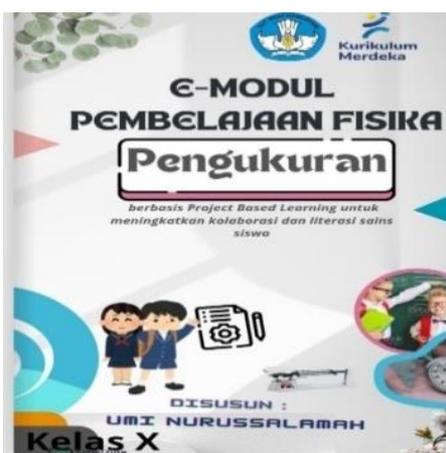
| Criteria | Category |
|--------------------|----------|
| $G \geq 0.7$ | High |
| $0.3 \geq G > 0.7$ | Medium |
| $G < 0.3$ | Low |

Result and Discussion

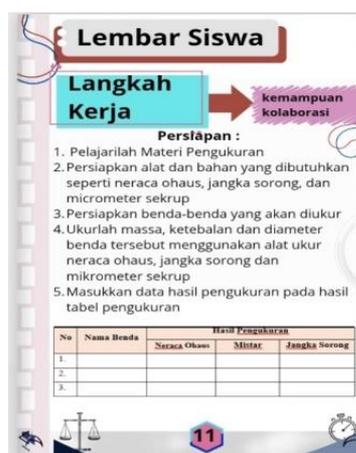
The product resulting from this development research is an E-Module on measurement material assisted by Heyzine flipbooks for senior high school's students. This E-module product is used as teaching material for physics measurement. It contains material, practice questions, PjBL steps, projects, and also evaluation. The final result of this e-module is a Heyzine flipbook which can be accessed via Android or computer.

Analysis

The initial phase of the ADDIE model involved identifying the needs and challenges faced by students in learning measurement concepts, particularly in terms of collaboration and scientific literacy. Through preliminary observations and surveys, it was found that traditional learning methods were insufficient in fostering active student engagement and collaboration. Previous studies have highlighted similar challenges, where conventional instructional approaches often fail to enhance students' problem-solving skills and critical thinking (Ardeleanu & Vasile, 2019; Tularam, 2018). In this stage the researcher also conducts interviews with teachers regarding learning activities in the classroom and also evaluates the learning needs based on project based learning.



(a)



(b)

Figure 1. Display of learning media: (a) E-Module Cover; and (b) Collaboration Stage

Design

In the second stage, namely design, this stage begins with preparing references related to measurement material and then preparing the media (Figure 2a). The media design was created using Canva and then exported to the Heyzine flipbook. We made measurement material briefly and clearly and the background design and images for each layout. When the design is ready it is then exported to the Heyzine flipbook and shared using a link so that it can be accessed by students. The E-Module was designed following PjBL principles, incorporating interactive elements and project-based tasks to promote collaboration and scientific literacy (Figure 2b). Research suggests that well-designed digital learning materials can significantly improve student engagement and comprehension (Navas Romero, 2025). The design phase also focused on aligning the E-Module with national curriculum standards to ensure its relevance and applicability in the classroom.



Figure 3. Syntax PjBl in e-Module

In syntax PjBl, the student groups are divided and viewing video shows in the form of measurement activities. Then students were distributed worksheet and watched a video about how to make a project and made a project agreement between the teacher and students. Teacher carries out monitoring students report project progress and sees the results of the students' projects. And in the final stage the teacher provides a conclusion on the material. All the step of syntax PjBl on the e-module as seen in Figure 3.

Development

Development stage, at this stage after the product has been developed, product and instrument feasibility testing will be carried out by a team of validation experts. Research validation was carried out by 2 experts. At this stage an evaluation was carried out on the e-module that had been designed to ensure the e-module was valid and in accordance with the learning objectives. Validity testing is a stage that aims to obtain input and suggestions to improve the quality of the media being developed. Suggestions and input provided by validators can be used as a reference to improve the learning media. At this stage, the results of product validation involve media expert validators and material experts to ensure the feasibility and validity of the e-module. The following are the results of e-module feasibility validation

Table 5. Module Validation Results

| Validation | Indicator | Validity Result | Category |
|-----------------|---|-----------------|----------|
| Media Expert | Appearance Presentation Reliability | 87.5% | Valid |
| Material Expert | Content of Material PjBl Language | 87.5% | Valid |

Based on the validation results of media experts and material experts, it is included in the valid category (Table 5). These findings align with previous research indicating that expert validation is crucial for ensuring the effectiveness and reliability of digital learning materials (Muzijah et al., 2020). The development phase also included iterative improvements based on feedback from the experts, ensuring the module's content, usability, and instructional design were optimized for student learning.

Implementation

The E-Module was implemented in a senior high school in Central Java, involving a limited trial with five students and a broader trial with 31 students. The practicality assessment demonstrated high student satisfaction. The practicality of e-modules based on project based learning can be seen from student responses, implementation of teaching module, and collaborations skill observation sheets. The results of the e-module feasibility or practicality test can be seen in the Table 6, Table 7, and Table 8.

Table 6. Student Responses

| Aspect | Score | Percentage % | Criteria |
|--------------|-------|--------------|----------------|
| Appearance | 435 | 87.7 | Very Practical |
| Presentation | 416 | 83.8 | Very Practical |
| Reliability | 203 | 81.8 | Practical |
| Average | 351.3 | 84.47 | Very Practical |

Table 7. Implementation of Teaching Module

| Aspect | Score | Percentage % | Criteria |
|----------------------|-------|--------------|----------------|
| Introduction | 4 | 100 | Very Practical |
| Core Activities | 7 | 100 | Very Practical |
| Authentic Assessment | 1 | 100 | Very Practical |
| Conclusion | 2 | 100 | Very Practical |

Table 8. Collaborations skill observation sheets

| Aspect | Percentage % | Criteria |
|--------------------------|--------------|----------------|
| Cooperation | 73.75 | Practical |
| Responsibility | 81.25 | Practical |
| Communication | 82.5 | Very Practical |
| Skills Working in Groups | 86.25 | Very Practical |
| Flexibility | 78.75 | Practical |
| Average | 80.5 | Practical |

Result of student response data using the developed project based learning e-module that was developed; it can be seen in the Table 5. Based on the results of student response data, the display aspect scored 87.7% with a very practical category. The presentation aspect scored 83.8% with a very practical category and reliability obtained a percentage of 81.8% with a practical category. This finding suggests that students found the visual design and layout of the E-Module engaging and conducive to learning. These results align with previous studies highlighting the importance of well-designed digital learning materials in enhancing student engagement and understanding (Aldhafeeri & Alotaibi, 2022; Chisunum & Nwadiokwu, 2024).

Apart from student responses, practicality is also assessed from the implementation of the teaching module in Table 6. The evaluation focused on whether the E-Module could be effectively integrated into classroom activities with minimal difficulty. The aspect of practicality received a very practical rating, confirming that teachers and students could seamlessly use the E-Module during project-based learning activities. These results are consistent with findings by Aldhafeeri & Alotaibi (2022), who emphasized that digital learning tools should be user-friendly and adaptable to various learning environments to maximize their impact.

Collaboration is a critical skill in 21st-century education, and the effectiveness of the E-Module in fostering teamwork was assessed through an observation sheet, with results presented in Table 7. The evaluation focused on 5 aspects of collaboration skills. Each of these aspects was categorized as practical and very practical, indicating that the PjBL E-Module successfully facilitated peer interaction and cooperative learning. The results of 2 aspects the collaboration skills were in very practical category, confirming that the E-Module successfully facilitated teamwork and peer learning. The emphasis on collaboration in project-based learning is well-documented in the literature. Studies by Hussein (2021) highlight that PjBL fosters deeper learning experiences by encouraging students to work together in solving complex problems. The findings of this study align with such research, demonstrating that an E-Module designed with collaborative elements can enhance teamwork skills effectively.

Moreover, the incorporation of collaborative tasks within the E-Module aligns with Vygotsky’s Social Constructivist Theory, which posits that learning is most effective when it occurs through social interaction. By providing structured collaboration opportunities, the E-Module enabled students to actively engage with

peers, share knowledge, and develop critical thinking skills.

Evaluation

The evaluation stage is the application of learning media using e-modules on based project based learning. Project based learning modules are said to be effective if their use achieves the expected goals. The aim of this research is to with the aim of knowing student responses as a whole and knowing the increase student’s collaboration and scientific literacy.

Table 9. Collaboration Skills Questionnaire Data

| Indicator | Pretest | Posttest | N-Gain | Category |
|--------------------------|---------|----------|--------|----------|
| Cooperation | 58.8 | 91.1 | 0.8 | High |
| Responsibility | 45.9 | 87.9 | 0.8 | High |
| Communication | 47.5 | 86.2 | 0.7 | Medium |
| Skills Working in Groups | 48.3 | 84.2 | 0.8 | High |
| Flexibility | 49.7 | 87.9 | 0.8 | High |
| Average | 50 | 87.9 | 0.8 | High |

The effectiveness of the developed Project-Based Learning (PjBL) E-Module in enhancing students' collaboration skills was measured using the N-Gain analysis. Table 9 presents the findings for each collaboration skill indicator, including cooperation, responsibility, group working skills, flexibility, and communication. The results indicate that cooperation, responsibility, group working skills, and flexibility obtained an N-Gain of 0.8 which falls into the high category, while the communication indicator achieved an N-Gain of 0.7, categorized as medium. These findings suggest that the integration of E-Modules with PjBL effectively fosters collaboration skills among students.

The high N-Gain in cooperation, responsibility, group working skills, and flexibility can be attributed to the inquiry-based and hands-on nature of PjBL, which encourages students to work collaboratively toward project completion (Fatmaryanti et al., 2022; Zitha et al., 2023). Through structured tasks requiring interdependence, students developed problem-solving abilities, enhanced team coordination, and cultivated mutual accountability, all of which align with the essential attributes of 21st-century learning (Fatmaryanti, 2024). The high engagement in collaborative tasks also aligns with previous studies that emphasize PjBL's role in fostering teamwork and critical thinking skills (Kurniahtunnisa et al., 2023; Rohmaniyah & Asih, 2024).

However, the communication indicator achieved a slightly lower N-Gain score (0.7, medium category). This could be due to students' varying proficiency in articulating scientific concepts and negotiating ideas effectively in group discussions. Previous research highlights that while PjBL encourages teamwork, students may require additional scaffolding in structured communication strategies to fully optimize their collaborative interactions (Winartiasih & Ulum, 2022). Future improvements in the E-Module could incorporate explicit instructional support for academic discourse, such as discussion prompts, peer feedback rubrics, and guided questioning techniques, to further enhance students' communication skills.

In comparison with previous research, the current study reinforces findings from Rehman et al. (2024), which demonstrated that PjBL improves student collaboration and engagement by integrating real-world applications with active learning strategies. Similarly, Hugerat (2016) found that students in PjBL classrooms exhibited higher collaboration scores compared to those in traditional learning environments.

The increase scientific literacy can be seen in Table 10. This study with (Maghfiroh et al., 2024) that there was a high increase in scientific literacy skill with an 0.71 using E-modules based on project based learning. From the result on the study, it was concluded that e-module was said to be feasible and could improve students' scientific literacy skill.

Table 10. Students' Scientific Literacy

| Components | Pre-test | Post-test | N-Gain | Category |
|--------------------|----------|-----------|--------|----------|
| Number of Students | | 31 | 0.74 | High |
| Lowest Score | 30 | 75 | | |
| Highest Score | 65 | 95 | | |

Research conducted by Humairah & Wahyuni (2024) using e-module obtained an N-Gain of 0.74 with a high category. This shows an increase in scientific literacy skills after the pretest (before) and posttest (after) treatment. Though project based learning (PjBL) students are faced with projects so that they are able to collaborate, think critically and apply the knowledge and skill they have in real contexts. This PjBL learning model involves students to be active in the learning process, through this model it also has a positive impact on improving scientific literacy skills, including

the development of 21st century skills (Ramadhan, 2023).

Conclusion

This study demonstrates that integrating E-Modules with Project-Based Learning (PjBL) is an effective approach to enhancing student collaboration and scientific literacy. Implemented The Project Based Learning based e-Module that is valid. 87.5% of the validity result from media expert with valid category. The results of the material expert validity equal to 87.5% with valid category. The results of the practical application and analysis of learning implementation obtained an average of 86.6% in the very practical category. Effectiveness is seen from a significant increase in collaboration abilities with an average score of 0.8 in the high category. These findings underscore the importance of innovative digital learning tools in fostering active engagement, critical thinking, and teamwork among students in measurement-related learning. The results suggest that this approach can be replicated or expanded to other topics to further enhance student-centered learning. Future research should explore the long-term impact of such digital interventions, assess their scalability, and investigate their integration with emerging educational technologies such as artificial intelligence and adaptive learning systems.

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Conflicts of Interest

The Authors declare no conflict of interest .

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