

## DEVELOPMENT OF A PHYSICS E-MODULE BASED ON TEAM-BASED PROJECT LEARNING (TBPL) INTEGRATED WITH IFP AND PHET SIMULATIONS TO IMPROVE STUDENT'S COLLABORATION SKILLS

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**Abstract:** This study aims to develop a physics e-module based on Team-Based Project Learning (TBPL) integrated with Interactive Flat Panel (IFP) and PhET simulations on the topic of Mechanical Energy Conservation and to examine its effectiveness in improving students' collaboration skills. The research method used was Research and Development (R&D) with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The subjects consisted of 26 students for the limited trial and 33 students for the field trial in grade X of SMA YPPK Tiga Raja Timika. The research instruments included collaboration skill observation sheets, student response questionnaires, and validation sheets from material and media experts. Data were analyzed using descriptive percentage analysis and Likert scale categories. The results showed that: (1) the e-module was highly feasible with an average material feasibility of 98% and media feasibility of 95%, with teacher and student responses of 100% and 97%, respectively; (2) the e-module effectively improved students' collaboration skills with an average score of 84.2% (very good category). In conclusion, the TBPL-based physics e-module integrated with IFP and PhET simulations is feasible and effective in improving students' collaboration skills in physics learning.

**Keywords:** e-module; Team-Based Project Learning; collaboration skills; PhET; IFP.

### 1. INTRODUCTION

Education in the 21st century requires a shift in learning paradigms, not only focusing on conceptual understanding but also on developing essential skills, one of which is collaboration. In line with the philosophy of Ki Hajar Dewantara, education must adapt to the demands of the era, including rapid advancements in digital technology. In this context, learning is no longer teacher-centered but emphasizes active, collaborative, and meaningful student engagement.

The Merdeka Curriculum emphasizes collaboration as an essential competency within the student profile, reflecting the ability to work together, communicate effectively, and respect differences to achieve common goals. However, observations at SMA YPPK Tiga Raja Timika indicate that students' collaboration skills are still not optimally developed. Students tend to work individually, show limited participation in group discussions, and lack responsibility sharing within teams.

This issue is further exacerbated by disparities in digital literacy, especially among students from remote or rural areas. Significant differences exist between students from urban areas and those from peripheral regions in terms of technology mastery. This condition affects students' participation in technology-based learning and hinders the development of effective collaborative interactions.

In physics learning, particularly in the topic of Mechanical Energy Conservation, understanding concepts requires interaction, discussion, and collaborative exploration. Therefore, an instructional approach that encourages active student involvement in group work is essential. One potential solution is the use of an e-module based on Team-Based Project Learning (TBPL) integrated with digital technologies such as IFP and PhET simulations. TBPL emphasizes teamwork through project completion, encouraging collaboration, communication, and shared responsibility. Based on this background, this study aims to: (1) develop a feasible TBPL-based physics e-module; and (2) analyze its effectiveness in improving students' collaboration skills.

## 2. RESEARCH METHODS

This study employed a Research and Development (R&D) approach using the ADDIE model, which consists of five stages: analysis, design, development, implementation, and evaluation. The analysis stage aimed to identify learning needs, student characteristics, and problems related to collaboration skills. The design stage involved structuring the e-module, designing its interface, and developing research instruments. The development stage included creating the e-module, conducting expert validation, and revising the product. Analysis of the validation results was conducted using a 1–4 Likert scale. The average scores were categorized based on eligibility criteria as proposed by Riduwan (2012) and Sugiyono (2019), as shown in Table 1 below:

**Table 1.** Validation Data Analysis

| Mean Score Range | Category      | Interpretation     |
|------------------|---------------|--------------------|
| 3.26 – 4.00      | Very Feasible | No Revision Needed |
| 2.51 – 3.25      | Feasible      | Minor Revision     |
| 1.76 – 2.50      | Less Feasible | Major Revision     |
| 1.00 – 1.75      | Not Feasible  | Total Revision     |

The implementation stage was carried out through limited and large-scale trials in grade X physics classes. Students worked in groups to complete projects using the e-module

integrated with IFP and PhET simulations. The evaluation stage included formative and summative evaluations to assess feasibility and effectiveness.

This research was conducted at SMA YPPK Tiga Raja Timika from January to February 2026. The population consisted of all grade X students. The sample included 26 students for the limited trial and 33 students for the field trial, selected using purposive sampling. The independent variable was the TBPL-based e-module, while the dependent variable was students' collaboration skills. Data were collected through observation and questionnaires measuring indicators such as active participation, communication, responsibility, decision-making, and reflection. Data analysis used percentage calculations with the formula:

$$\text{Percentage} = \frac{\text{Observed Aspect}}{\text{Total Aspect}} \times 100\%$$

The assessment criteria are determined based on the classification proposed by Arikunto (2013) and Riduwan (2012), as shown in Table 2 below:

**Table 2.** Assessment Criteria

| Percentage | Category  |
|------------|-----------|
| 81–100%    | Very Good |
| 61–80%     | Good      |
| 41–60%     | Fair      |
| 21–40%     | Poor      |
| ≤20%       | Very Poor |

### 3. RESULTS AND DISCUSSIONS

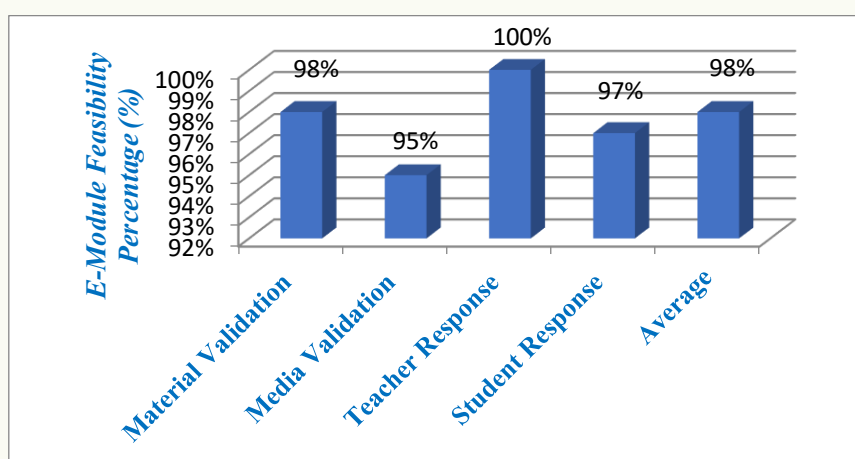
This study produced a physics e-module based on TBPL integrated with IFP and PhET simulations for the topic of Mechanical Energy Conservation. The e-module was developed in alignment with the learning objectives and curriculum structure of the Merdeka Curriculum. It was designed using Heyzine Flipbooks to enhance conceptual understanding, collaboration skills, and character development.

The e-module consists of three main sections:

- 1) Introduction Section: Cover, preface, table of contents, concept map, and user guidelines
- 2) Main Content: Learning objectives, indicators, prerequisite concepts, materials, videos, and student worksheets
- 3) Evaluation Section: Pre-test, post-test, answer keys, glossary, references, and author profile

### Feasibility of the E-Module

The results of the feasibility analysis, validated by material experts, media experts, and supported by teacher and student responses, are presented in Figure 1.

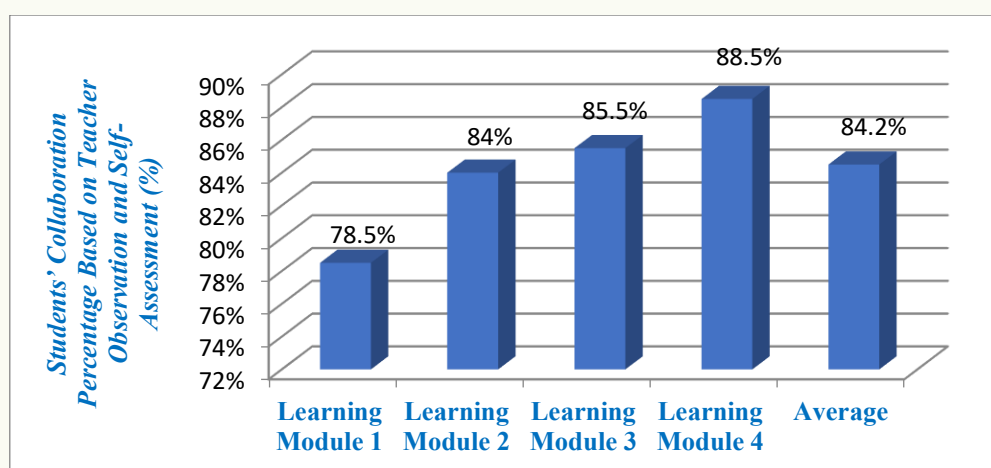


**Figure 1.** Feasibility Scores of the E-Module

The validation results indicate that the e-module is categorized as highly feasible. Material feasibility reached 98%, and media feasibility was 95%. Teacher and student responses were 100% and 97%, respectively, indicating very positive acceptance. This confirms that the e-module meets the criteria of an effective learning resource in terms of content quality, design, and usability.

### Improvement of Collaboration Skills

The results of collaboration skill analysis based on observations and student self-assessment are presented in Figure 2.



**Figure 2.** Students' Collaboration Skills from Module 1 to Module 4

The findings indicate a consistent improvement in students' collaboration skills across each meeting. The percentage of collaboration increased progressively from 78.5% in Module

1 to 84% in Module 2, followed by 85.5% in Module 3, and reaching 88.5% in Module 4. Overall, the average collaboration score attained 84.2%, which falls into the very good category. This improvement was evident across several key aspects, including active participation, effective communication, group responsibility, shared decision-making, and reflective practices. These results suggest that the implementation of the Team-Based Project Learning (TBPL) model, supported by the developed e-module, effectively fosters and strengthens collaborative learning among students.

#### 4. CONCLUSIONS AND SUGGESTIONS

##### CONCLUSIONS

Based on the research findings, it can be concluded that The TBPL-based physics e-module integrated with IFP and PhET simulations is highly feasible for use in learning. The e-module effectively improves students' collaboration skills, with an average score of 84.2% (very good category).

##### SUGGESTIONS

The TBPL-based e-module can be used as an alternative learning resource to improve collaboration skills, further research is recommended to use experimental designs with control groups for more objective comparisons.

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