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Enhancing High School Students' Critical Thinking in Economics through Project-Based Learning Supported by E-Modules: Evidence from the Indonesia–Timor-Leste Border

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ABSTRACT

In real life, the economy is open and continuously developing, so in its learning, critical thinking skills are needed to make it easier to understand. Students need to be taught to connect the theoretical concepts taught in the classroom with real-world situations. Project-Based Learning supported by an e-module is present to overcome this issue. However, several studies have focused on science subjects or urban contexts and have not specifically addressed border (3T) regions. In this study, we examined the effectiveness of the Project-Based Learning supported by the e-module model in improving students' critical thinking skills in high school economics learning in the context of Indonesia's border regions. For this purpose, we used a quasi-experimental method with a non-equivalent Control Group design involving 162 eleventh-grade students from public senior high schools in Malaka Regency, at the Indonesia–Timor Leste border. The students were divided into two groups: the experimental group, which was given the Project-Based Learning supported by e-module treatment, and the control group, which used traditional textbook-based methods. To measure students' critical thinking skills, 20 HOTS-level questions that had been tested for validity and reliability were administered. For comparison, we analyzed the covariance (ANCOVA) test by controlling the pretest variable. The results of this study showed that the Project-Based Learning supported by the e-module proved to be more effective than the traditional method. This result was also supported by questionnaire findings showing that almost all students considered the Project-Based Learning supported by e-module learning to be interesting and enjoyable.

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1. INTRODUCTION

Critical thinking skills are essential in the 21st century, enabling students to analyze and evaluate everyday phenomena. In economics learning, critical thinking enables students to analyze, evaluate data and make decisions based on logic and rational evidence. However, in practice, economics learning in most senior high schools still focuses on memorization rather than analysis and problem-solving, which require students to think critically (Acheampong et al., 2023; Hermidayani et al., 2019; Idakwoji et al., 2025). As a result, students often find it difficult to understand current economic issues such as inflation, price changes, price indices, and exchange rates, which demand deeper analytical skills.

Findings from the PISA (2022) and the Minimum Competency Assessment (AKM) (Kemendikbudristek, 2022; OECD, 2022) revealed that Indonesian students' higher-order thinking skills remain relatively low. This indicates that most students are still unable to connect theoretical concepts with real-life contexts. Such conditions highlight the importance of implementing learning approaches that can activate students' thinking, reasoning, and problem-solving processes in economics learning.

With the advancement of digital technology, modern education has transformed by offering interactive, flexible, and adaptive learning resources suited to students' characteristics (Contrino et al., 2024; Dritsas & Trigka, 2025). One of the widely used digital learning media is the e-module, which is accessible, interactive, and responsive (Putra et al., 2023). Several studies have shown that the use of e-modules can enhance students' motivation, interest, and critical thinking skills (Al-Emran et al., 2016; Alim et al., 2025; Dermawan et al., 2025). However, the utilization of e-modules in Indonesian schools remains suboptimal. Preliminary interviews conducted in several senior high schools in Malaka Regency, at the Indonesia – Timor Leste border, revealed that economics learning is still dominated by traditional textbook-based methods. This finding aligns with previous reports (BPS, 2023; UNICEF Indonesia, 2021), which show that most teachers and students still rely on printed learning resources. Even though 72% of schools have begun digital transformation, only around 35% have implemented it effectively—especially in remote areas (Yanita, 2025), resulting in underdeveloped students' critical thinking skills (Elfeky et al., 2025).

Maros et al., (2023) stated that various non-traditional learning methods can stimulate curiosity, creativity, and student motivation to participate actively in class. These methods transform passive learning into active learning, where students become more independent participants in their own learning processes (Hudáková & Papcunová, 2019). Active learning methods have a positive impact on students' participation, interaction, and communication, such as through role-playing, games, case studies, problem-based learning (PBL), and project-based learning (PjBL), which is the focus of this research

Project-Based Learning (PjBL) is a learning model that emphasizes in-depth investigation of authentic problems through students' active involvement in projects that are relevant to real life. This approach enables students not only to acquire conceptual knowledge but also to develop analytical and reflective skills, independence, creativity, as well as collaboration and communication skills (Dias-Oliveira et al., 2024; Rehman et al., 2025; Sari et al., 2025; Shi & Li, 2024; Cortázar et al., 2021; Mubarok et al., 2025; Sánchez-García & Reyes-de-Cózar, 2025; Setiaji et al., 2025; Skliarova, 2021). PjBL is considered effective because it emphasizes direct experience in solving real-world problems rather than merely understanding abstract concepts, and it represents a shift in the learning paradigm from teacher-centered to student-centered learning (Maros et al., 2023; Sari et al., 2024). In line with this, various studies have shown that PjBL is consistently more effective than traditional methods in improving critical thinking skills, both in science and social science fields (Tafakur et al., 2023; Khafah

et al., 2023; Montessori et al., 2024; Nielsen, 2024; Tambunan, et al. 2024). Studies on PjBL in economics education have also been shown to be effective (Chmelárová & Čonková, 2021; Maros et al., 2023; Robles et al., 2025). This indicates strong potential that PjBL can improve students' critical thinking skills in economics. However, to be more effective, PjBL needs to be supported by e-modules as interactive and flexible learning resources for students.

A number of studies have demonstrated that both PjBL and e-modules, when used separately, can improve learning outcomes, creativity, and critical thinking skills (Mardiana et al., 2025; Skliarova, 2021; Tafakur et al., 2023). The integration of PjBL and e-modules provides flexibility and interactive support that can strengthen the critical thinking process (Pitorini et al., 2024). Nevertheless, these studies still have several limitations. First, they were conducted in developed countries such as Spain and Slovakia, where educational and digital infrastructures are already well established—conditions that differ significantly from the Indonesian context, particularly in the 3T (frontier, outermost, and disadvantaged) areas such as Malaka Regency, East Nusa Tenggara, which borders Timor-Leste. In these regions, limited resources, learning facilities, and technological infrastructure remain major challenges in the learning process. Second, the topics studied did not focus on specific high school economics content, such as price indices and inflation, which require advanced critical thinking skills because they involve data analysis and an understanding of real-world price phenomena. Third, the research is still largely descriptive or focused on students' perceptions (Chmelárová & Čonková, 2021; Maros et al., 2023; Robles et al., 2025). In addition, most studies on e-module-supported PjBL have focused on science and STEM fields, especially at the elementary school level (Dwiningsih et al., 2024; Yao, 2025).

Based on the above review, this study focuses on empirically examining the effectiveness of Project-Based Learning supported by an e-module in enhancing high school students' critical thinking skills in economics learning in Malaka Regency, a border region between Indonesia and Timor-Leste. This research is expected to provide a meaningful contribution to developing contextual, innovative, and student-centered economics learning strategies in 3T areas. In line with this objective, the study seeks to answer the following question: Is e-module–based PjBL more effective than traditional instruction in improving senior high school students' critical thinking skills in economics?

2. METHODS

To test the research hypothesis, we employed an experimental approach using a non-equivalent control group design. Through this design, we did not have full control to randomly assign participants to the experimental and control groups (Creswell, 2014). In this design, the independent variable was the learning method: Project-Based Learning supported by an e-module and traditional learning using textbooks, which was manipulated to examine its effect on the dependent variable, namely, students' critical thinking skills. The quasi-experimental method was chosen because it allowed partial control over external variables while maintaining the natural conditions of the learning process in schools. In addition to the experimental approach, a questionnaire was also used to obtain comprehensive data on students' perceptions of project-based learning. This study has obtained ethical approval from the school and the local education authority. Participants' identities were kept confidential, and all research procedures were conducted in accordance with educational research ethics principles.

This study was conducted in 2025 over five weeks, consisting of four learning sessions (90 minutes each) and one session for the pretest (45 minutes), at three public senior high schools in Malaka Regency, Indonesia, Timor Leste border. The topic taught in this study was Price Index and Inflation, one of the main subjects in eleventh-grade students specializing in economics. Therefore, eleventh-grade students specializing in economics classes from each school were selected as research participants. A total of 162 students were involved, consisting of 80 students in the experimental group

and 82 students in the control group. The experimental group learned economics through the Project-Based Learning supported by the e-module model, while the control group followed traditional textbook-based learning. Both groups were taught by the same teacher to ensure equivalent learning conditions.

The preparation stage included developing lesson plans, e-module, and research instruments for both groups; validating the instruments by experts; and providing teacher training to ensure a clear understanding of the implementation flow of Project-Based Learning supported by the e-module. The implementation stage began with administering a pretest to both groups to measure students' initial abilities. Next, the experimental group received instruction using the Project-Based Learning supported by the e-module model, while the control group did not receive any treatment. After all sessions were completed, a posttest was administered to both groups to assess the improvement in students' critical thinking skills. In addition to comparing critical thinking outcomes, students in the experimental group were also asked to complete a questionnaire to gather their opinions on the project-based learning experience.

In the experimental group, students engaged in several project stages: (1) identifying local economic problems related to rising prices and inflation in their surroundings; (2) conducting interviews with nearby vendors to collect data on the prices of basic goods at two different time periods; (3) calculating the Price Index and Inflation Rate based on the collected data; (4) analyzing the causes of price changes and their effects on purchasing power; (5) presenting project results in the form of an infographic that visually and informatively displays the inflation calculations and analysis; and (6) presenting their projects in class, followed by reflection and feedback sessions from teachers and peers (Elfeky et al., 2025; Maros et al., 2023; Wang, 2022; Wickramasinghe & Appiah, 2024). The e-module used in this study was developed as a supporting medium for PjBL and was accessed online through students' mobile devices or laptops. It includes concept maps, brief material summaries, usage guidelines, and content on Price Index and Inflation enriched with case examples. The e-module also provides practice exercises, YouTube video links, and project steps to guide students in project-based learning. It was designed to be interactive and flexible.

The test instrument used in this study consisted of 20 multiple-choice items based on Higher Order Thinking Skills (HOTS), which had been validated and tested for reliability. The test was developed based on critical thinking indicators adapted from Anderson & Krathwohl (2001) revised taxonomy, focusing on three higher-order cognitive domains: analyzing (C4), evaluating (C5), and creating (C6). C4 items measured the ability to analyze causes of inflation, compute price and inflation indices from numerical data, classify inflation types based on cases, and relate monetary and fiscal policies to their impacts. C5 items assessed evaluation of the impacts and effectiveness of inflation control policies, while C6 items required data-based logical conclusions on inflation and consumption behavior. Although multiple-choice in format, C6 items were stimulus- and scenario-based, requiring information synthesis and selection of the most logical conclusion. Initially, the test contained 25 items, which were validated by three experts using the Content Validity Index (CVI), yielding a high level of agreement (S-CVI/Ave = 0.96). After item analysis, 20 items met the eligibility criteria. The validity test showed that 23 items were valid, with r-values ranging from 0.321 to 0.658 (r table = 0.334; n = 35). The reliability analysis using the Kuder Richardson-20 (KR-20) formula produced an r_{11} value of 0.846, indicating very high reliability. The difficulty level of the items was moderate (p = 0.49–0.74; mean = 0.61), while the discrimination index ranged from good to very good (r_pb = 0.36–0.67; mean = 0.50). The items covered topics related to price changes, price index, and inflation, consisting of 14 analytical, 4 evaluative, and 2 creative questions. The questionnaire validity test showed that three items (Items 1, 5, and 7) were valid ($r = 0.593–0.667$; $p < 0.01$), while four items were removed. Reliability analysis

produced a Cronbach's alpha of 0.752, indicating high reliability. Two open-ended questions were added to enrich the descriptive analysis of students' perceptions.

The data analysis technique employed was Analysis of Covariance (ANCOVA) to determine the difference in posttest results between the experimental and control groups while controlling for the pretest score as a covariate. Before conducting the main analysis, several prerequisite tests were performed, including the D'Agostino–Pearson test for normality, homogeneity of variance, linearity, and homogeneity of regression slopes. Statistical analysis was conducted using R Studio software with a significance level of 0.05. ANCOVA was selected because the participants were not randomly assigned to the experimental and control groups, which might have resulted in differences in initial ability levels (Field, 2016). Therefore, the pretest score was used as a covariate to ensure that the posttest results accurately reflected the treatment effect. The effect size was calculated using Cohen's (Cohen, 1988) d, categorized as negligible ($d \leq 0.2$), small ($0.2 < d < 0.5$), medium ($0.5 \leq d < 0.8$), and large ($d \geq 0.8$). In addition to quantitative analysis, data from the questionnaire were analyzed descriptively to provide insights into students' perceptions of the implementation of Project-Based Learning supported by an e-module in economics learning.

3. FINDINGS AND DISCUSSION

After the learning process using the Project-Based Learning supported by the e-module in the experimental group and the traditional textbook-based learning model in the control group, we calculated the level of students' critical thinking skills involved in the study (Table 1).

Table 1. Descriptive Statistics of Research Data

Statistics	PjBL (e-module)		Traditional (Texbook)	
	Pretest	Posttest	Pretest	Posttest
n	80	80	82	82
Mean	23.38	69.12	24.21	57.38
SD	9.37	14.38	11.43	15.56
Median	25	70	25	55
Min	5	30	5	15
Max	45	100	55	90
Range	40	70	50	75
Skewness	-0.19	-0.16	0.36	-0.19
Kurtosis	-0.93	0.09	-0.48	0.05
SE (Std. Error)	1.05	1.61	1.26	1.72

In the pretest stage, both groups showed relatively comparable initial scores (PjBL = 23.38; Control = 24.21), so the initial conditions can be considered equivalent. After treatment, the experimental group obtained a mean score of 69.12, while the control group achieved only 57.37This pattern shows that there is an interaction between the pre-posttest and the learning group (Figure 1). At a 95% confidence interval, we calculated the adjusted mean after controlling for the pretest scores (Table 2). This difference indicates that the experimental group performed better than the control group. Accordingly, the following hypotheses were tested for statistical significance:

H_0 (null hypothesis): There is no statistically significant difference in students' economic critical thinking skills between the experimental and control groups after controlling for the pretest.

H_1 (alternative hypothesis): There is a statistically significant difference in students' economic critical thinking skills between the experimental and control groups after controlling for the pretest.

Table 2. Adjusted Means and 95% Confidence Intervals

Group	Adjusted Mean	SE	df	95% CI (Lower–Upper)
PjBL (E-Module)	69.4	1.56	159	66.3 – 72.4
Traditional (Textbook)	57.2	1.54	159	54.1 – 60.2

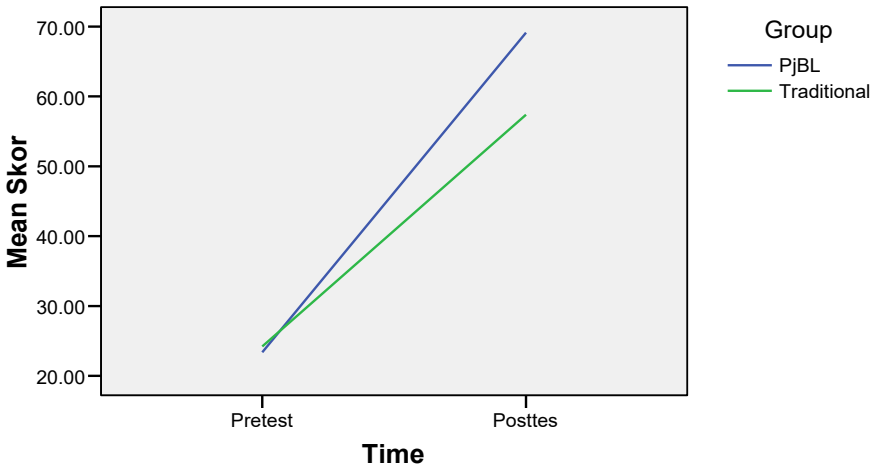

Figure 1. Interaction Group with Pre-Posttest

We used a covariate analysis test to examine the hypothesis at a 5% significance level. Before testing, the assumptions of normality, homogeneity of variance, linearity, and homogeneity of regression slopes must be satisfied.

Table 1 presents the kurtosis value for the experimental group as 0.09 and for the control group as 0.05, while the skewness for the experimental group is -0.16 and for the control group is -0.19. According to the criteria by George & Mallery (2010) data is considered normal if the skewness and kurtosis values are within the range of -2 to +2. For further testing, we used the D'Agostino–Pearson residual normality test. The result for the residuals showed a p-value of 0.7199 ($p > 0.05$). Thus, the data in this study meet the normality assumption, so parametric ANCOVA analysis can be conducted. Next, we conducted a linearity test by adding a squared component (Pretest²) to the model to ensure the relationship between pretest and posttest scores is linear.

The analysis results showed that the Pretest² component is not significant ($F = 0.597$; $p = 0.440$), meaning that the relationship between pretest and posttest scores is linear. The homogeneity of regression slopes test is also satisfied, as seen from the interaction result between group and pretest (Group × Pretest) with a value of $F = 0.791$; $p = 0.375$ ($p > 0.05$). Therefore, the data meet the assumptions of linearity and homogeneity of slopes, so the ANCOVA analysis can proceed to test the differences in learning outcomes between the two groups.

The ANCOVA results show that the group variable obtained a p-value of 0.000 (p-value < 0.05), indicating that after controlling for pretest, there is a significant difference between the experimental group and the control group. In addition, the pretest variable also has a significant effect on the posttest, meaning students' initial scores also have a significant impact on the posttest. Thus, it can be concluded that the null hypothesis is rejected; there is a statistically significant difference in students' critical economic thinking abilities between the experimental group and the control group after controlling for pretest scores.

The effect size calculation using Cohen's d shows a value of 0.78, which is considered moderate. The 95% confidence interval falls within the range of 0.46 – 1.11, indicating that the impact of PjBL model-supported e-module on improving students' critical thinking skills is quite strong and practically significant. This effect size indicates that e-module–based PjBL is worth considering as an instructional strategy for senior high school economics learning.

Table 3. ANCOVA Test

Source of Variation	Df	Sum Sq	Mean Sq	F	Sig. (Pr > F)	Description
Group	1	5587.8	5587.8	28.60	0.000 (***)	Significant
Pretest	1	5009.0	5009.0	25.64	0.000 (***)	Significant
Pretest²	1	116.7	116.7	0.60	0.4407	Not Significant
Group × Pretest	1	154.5	154.5	0.79	0.3751	Not Significant
Residual (Error)	157	30669.8	195.3	–	–	–

Signif. codes: *** p < 0.001; ** p < 0.01; * p < 0.05.

We also examined other perceived benefits of the Project-Based Learning model supported by the e-module in the experimental group through a questionnaire using a four-point Likert scale (4 = strongly agree; 3 = agree; 2 = disagree; 1 = strongly disagree) to avoid neutral responses. The results showed that 58.75% of students "strongly agreed" and 41.25% "agreed" that the model was enjoyable. None of the students selected "disagree" or "strongly disagree." For the statement that the model helped students understand the material more deeply, 48.75% of students chose "strongly agree" or "agree," while only 2.5% chose "disagree." Additionally, 45% of students "strongly agreed" and 38.75% "agreed" that the e-module was easier to understand than traditional materials, whereas only 16.25% disagreed. Although these results were positive, a small number of students still required guidance or adaptation during the Project-Based Learning process. Nevertheless, we believe that the Project-Based Learning supported by the e-module model provided an engaging and enjoyable learning experience for students.

When asked which activities they enjoyed most from the Project-Based Learning supported by e-module implementation, most students mentioned working on projects and group collaboration. Some also appreciated the easy access and interactivity of the e-module, although these responses were less frequent than those related to project work. Regarding challenges encountered during e-module use, the majority of respondents reported no significant difficulties—43.75% answered "none," and 47.5% stated "no difficulties," indicating that most students found the e-module easy to use. Only 8.75% mentioned minor challenges, such as lack of motivation, technical issues, or difficulty understanding material without teacher assistance. These findings demonstrate that the Project-Based Learning supported by the e-module model was well-received by students, with minimal challenges reported during its implementation.

In this study, our focus was to examine the effectiveness of Project-Based Learning supported by an e-module in enhancing students' critical thinking skills in Malaka Regency, a border region near Timor-Leste. To evaluate its effectiveness, we conducted a quasi-experimental study in three public senior high schools in the district.

Economics learning involves conceptual, mathematical, and graphical analyses. When presented with economic data, students often struggle to interpret its meaning. Here, the role of educators is essential in developing effective strategies to help students connect theoretical knowledge with real-world data. Maros et al., (2023) emphasize that economics learning at the secondary level aims to prepare students to adapt to changes in daily life, making teacher and student engagement during the learning process crucial.

Project-Based Learning (PjBL) has been shown to have a greater impact on students' critical thinking than traditional methods (Duncan, 2020; Sudarwati et al., 2025; Tohani, & Aulia 2022). Through PjBL, students work on real-world problems, connecting theory and practice, which enhances their independence and critical thinking (Madsen & Olesen, 2019). Therefore, we assumed that an approach emphasizing the integration of theoretical and empirical aspects—such as PjBL—would better help students link theory with real-world contexts, thereby improving critical thinking compared to traditional methods. Students in the experimental group demonstrated higher critical thinking performance than those in the control group, confirming our research hypothesis.

In this study, students conducted a project identifying issues related to rising prices in their local communities by interviewing local vendors to collect price data on basic needs. These data were then processed into infographics representing the Price Index and Inflation. Through this activity, students learned to connect theoretical concepts taught in class with real-world economic situations. Calculating price indices and inflation based on actual data helped them understand abstract concepts while realizing the relevance of economics in daily life. This aligns with constructivist theory, which emphasizes meaningful learning through active experience (Mardiana et al., 2025; Skliarova, 2021; Tafakur et al., 2023). Purba, (2023) states that price index material is a key indicator for understanding inflation and macroeconomic dynamics. Thus, the projects undertaken by students in this study not only help them understand theory, but also analyze empirical data as practiced in real-world economics. The connection between theory and real-life experience is also reinforced by Linh, (2024). When students process price data, create graphs, and design infographics, they are essentially building economic understanding through guided and authentic investigative activities. These activities strengthen the connection between theory and practice as well as academic social interaction through collaboration and projects, which contribute to the development of their critical thinking processes (Arga & Sapriya, 2024; Haryanti et al., 2024; Haswan et al., 2024; Nagamalla et al., 2024; Tusino et al., 2024; Winarko, 2024). This is consistent with our questionnaire results, which showed that almost all students in the experimental group found this learning approach enjoyable, with the project component being their favorite part.

In addition to the project-based approach, we provided students with e-modules as a learning support tool. According to Agustina et al. (2022); Serevina et al. (2022) e-modules are engaging and useful for developing students' language and vocabulary skills. The interactive elements of e-modules enhance motivation, engagement, and collaboration (Handayani & Nurhamidah, 2024; Wang & Sitthiworachart, 2024), while fostering communication and teamwork skills relevant to future demands (Arga & Sapriya, 2024). The questionnaire results also revealed that most students agreed that e-modules were easier to understand than printed learning materials. These findings reinforce the idea that e-modules are not only practical and engaging but also effective in helping students comprehend materials more easily.

The observed effect falls within the moderate-to-near-large range, indicating a meaningful educational impact, although it has not yet reached a large effect. We suggest that this may be due to the relatively short duration of the intervention, the analytical–numerical nature of the content, and students' still limited familiarity with project-based learning and the use of digital modules. We also considered the contextual conditions, as 3T/border regions continue to face digital infrastructure constraints and varying levels of teacher readiness in implementing technology-based PjBL. In practice, we found that some students experienced network difficulties and required more intensive guidance throughout the project process. This is consistent with previous studies indicating that student attitudes are not always positive (Ospankulova et al., 2025), teachers may have limited experience implementing PjBL and 4C skills (Priyohutomo et al., 2024) and technical issues remain an obstacle despite the

flexibility of technology-based learning (Ansari et al., 2024). In our view, these factors also limited the magnitude of the intervention's impact, although the direction of the effect remained positive.

We conclude that Project-Based Learning supported by an e-module is proven effective not only in enhancing students' critical thinking skills but also in enriching their learning experiences compared to traditional methods. However, this does not imply that traditional methods should be completely replaced. Rather, we recommend this model as an engaging and equally effective alternative for teachers to foster students' critical thinking, particularly in economics topics such as price indices and inflation.

4. CONCLUSION

Our study demonstrates that the Project-Based Learning (PjBL) model supported by an e-module is significantly more effective in improving students' critical thinking skills than traditional textbook-based methods. Students who participated in PjBL supported by an e-module showed a deeper understanding of economic concepts—particularly in the topic of price index and inflation—as they were directly involved in project activities that connected theory with real-world situations. Furthermore, questionnaire results indicated that most students found this learning approach enjoyable, interactive, and easier to understand through e-modules. Theoretically, this study contributes to strengthening and extending the application of PjBL in the context of economics learning in 3T/border regions, showing that the integration of PjBL and digital e-modules remains effective even under limited infrastructure conditions. However, this study has several limitations. First, it was conducted only in three public high schools in Malaka Regency, so the findings cannot be generalized to broader contexts. Second, the research duration was relatively short, making it difficult to determine the long-term impact of PjBL supported by the e-module. Third, some students still required intensive guidance and faced technical challenges in using e-modules. Therefore, future efforts should include teacher training for implementing technology-based PjBL and providing adequate digital infrastructure, particularly in remote areas (3T regions), so that project-based learning can be implemented more effectively and equitably.

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