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# Analysis of the Implementation of a Problem-Based Learning (PBL)-Based IPAS E-Module on Elementary School Students' Conceptual Understanding and Critical Thinking Skills

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## ABSTRACT

This study aims to analyze the effect of implementing a Problem-Based Learning (PBL)-based IPAS e-module on elementary school students' conceptual understanding and critical thinking skills. The problem underlying this study is the low level of students' conceptual understanding and critical thinking skills in IPAS learning. This study employed a quantitative approach with a quasi-experimental design, specifically a nonequivalent control group design. The research sample consisted of 31 students divided into a control class and an experimental class. The instruments used included a conceptual understanding test and a critical thinking skills questionnaire. The results showed a significant improvement in the experimental class compared to the control class. The average posttest score in the experimental class (31.47) was higher than that of the control class (23.44), with a gain of 10.94 in the experimental class and 2.88 in the control class. The hypothesis test results showed that the calculated t-value was greater than the t-table value, and the significance value was less than 0.05, indicating a significant difference between the two groups. The conclusion of this study is that the Problem-Based Learning (PBL)-based IPAS e-module is effective in improving students' conceptual understanding and critical thinking skills. This study implies that the integration of learning technology and problem-based models can improve the quality of IPAS learning in elementary schools and support the development of 21st-century skills.

**Informasi Artikel**

**Kata Kunci:**

*e-modul, Problem Based Learning, pemahaman konsep, berpikir kritis, pembelajaran IPAS*

## ABSTRAK

Penelitian ini bertujuan untuk menganalisis pengaruh implementasi e-modul IPAS berbasis Problem Based Learning (PBL) terhadap pemahaman konsep dan keterampilan berpikir kritis siswa sekolah dasar. Permasalahan yang melatarbelakangi penelitian ini adalah rendahnya kemampuan pemahaman konsep dan berpikir kritis siswa dalam pembelajaran IPAS. Penelitian ini menggunakan pendekatan kuantitatif dengan desain quasi-experimental, yaitu nonequivalent control group design. Sampel penelitian terdiri dari 31 siswa yang terbagi menjadi kelas kontrol dan kelas eksperimen. Instrumen yang digunakan meliputi tes pemahaman konsep dan angket keterampilan berpikir kritis. Hasil penelitian menunjukkan bahwa terdapat peningkatan yang signifikan pada kelas eksperimen dibandingkan kelas kontrol. Nilai rata-rata posttest pada kelas eksperimen (31,47) lebih tinggi dibandingkan kelas kontrol (23,44), dengan gain sebesar 10,94 pada kelas eksperimen dan 2,88 pada kelas kontrol. Hasil uji hipotesis menunjukkan bahwa nilai t hitung lebih besar dari t tabel serta nilai signifikansi lebih kecil dari 0,05, yang menunjukkan adanya perbedaan signifikan antara kedua kelompok. Kesimpulan penelitian ini adalah bahwa e-modul IPAS berbasis Problem Based Learning (PBL) efektif dalam meningkatkan pemahaman konsep dan keterampilan berpikir kritis siswa. Penelitian ini memberikan implikasi bahwa integrasi teknologi pembelajaran dan model berbasis masalah dapat meningkatkan kualitas pembelajaran IPAS di sekolah dasar serta mendukung pengembangan keterampilan abad ke-21.

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## 1. Introduction

The rapid development of the 21st century requires education systems to focus not only on students' mastery of factual knowledge but also on the development of higher-order thinking skills, particularly critical thinking and problem-solving skills. At the elementary school level, these skills are essential because they serve as the foundation for students' future cognitive development. However, various studies indicate that elementary school students' critical thinking skills remain relatively low, especially in science learning. Recent findings show that fewer than 40% of elementary school students are able to achieve critical thinking indicators at the levels of analysis and evaluation in science learning [1], [2]. This condition presents a serious challenge for improving the quality of education in accordance with the demands of the 21st century.

In the Indonesian context, students' conceptual understanding and critical thinking skills in science learning are still categorized as low to moderate. Many students experience difficulties in connecting scientific concepts with phenomena in everyday life [3]. This problem is further intensified by learning practices that are still predominantly teacher-centered, limiting students' opportunities to explore, investigate, and construct knowledge independently. Therefore, an innovative learning approach is needed to encourage students to become active learners and to support the development of deeper conceptual understanding.

The implementation of the Merdeka Curriculum in elementary schools emphasizes contextual, integrative, and problem-based learning through IPAS, or Natural and Social Sciences. IPAS learning is expected to help students understand natural and social phenomena in an integrated manner. Nevertheless, in practice, the use of innovative learning media that can actively engage students remains limited. One promising solution is the use of e-modules as interactive digital teaching materials. E-modules are considered effective because they can present learning materials systematically, interactively, and flexibly, allowing students to learn both independently and collaboratively [4], [5].

An e-module is not merely a digital version of printed teaching material. It can contain learning objectives, explanations, exercises, evaluations, multimedia elements, guiding questions, and interactive activities that support students' learning processes. In elementary science learning, e-modules can help students understand abstract concepts through texts, images, videos, links, and contextual learning tasks [5]. However, the effectiveness of e-modules depends greatly on the learning model used in their design. Therefore, e-modules need to be integrated with a pedagogical approach that promotes active learning, reasoning, and reflection.

Problem-Based Learning (PBL) is one learning model that has been proven to support students' critical thinking and problem-solving skills. PBL uses real-world problems as the starting point of learning, encouraging students to identify problems, collect information, analyze evidence, propose solutions, and draw conclusions [6]. In this model, teachers act as facilitators, while students become active participants in constructing knowledge. The characteristics of PBL are highly relevant to IPAS learning because students are required to connect concepts with real situations in their social and natural environments [2], [6].

The integration of e-modules and PBL offers a potential innovation for improving the quality of IPAS learning in elementary schools.

Through PBL-based e-modules, students are not only provided with digital learning materials but are also guided to solve contextual problems through structured learning activities. Previous studies have shown that STEM-based e-modules with a PBL approach can significantly improve elementary school students' critical thinking skills [1]. Other studies also indicate that PBL-based e-modules can enhance science literacy, critical thinking, collaboration, communication, and creativity as part of 21st-century skills [6], [7].

Although previous studies have shown the effectiveness of e-modules and PBL in improving learning outcomes, critical thinking, and science literacy, several research gaps remain. Many studies have focused only on one dependent variable, such as learning outcomes or critical thinking skills [8]. Research that simultaneously examines the effect of PBL-based e-modules on both conceptual understanding and critical thinking skills is still limited, particularly in the context of IPAS learning in elementary schools. In addition, many previous studies have used descriptive or research and development designs, while quasi-experimental studies that provide stronger empirical evidence are still relatively limited [3], [9].

Another limitation of previous research is the lack of integration between contextual IPAS content and problem-based learning design in e-modules. In fact, contextual and problem-based learning is important to help students understand concepts more deeply and apply them to real-life situations [10]. Therefore, research that comprehensively integrates IPAS content, digital e-modules, and the PBL model is needed.

Based on these gaps, this study aims to analyze the effect of implementing a Problem-Based Learning-based IPAS e-module on elementary school students' conceptual understanding and critical thinking skills. This study employs a quantitative approach with a quasi-experimental design to obtain empirical evidence regarding the effectiveness of the learning intervention. The hypotheses of this study are: first, there is a significant difference in conceptual understanding between students who learn using PBL-based e-modules and those who learn through conventional instruction; second, there is a significant difference in critical thinking skills between the two groups; and third, PBL-based e-modules have a positive simultaneous effect on students' conceptual understanding and critical thinking skills. This study is expected to contribute to the development of innovative digital learning materials and provide practical insights for improving the quality of IPAS learning in elementary schools.

## 2. Method

This study employed a quantitative approach with a quasi-experimental design. This design was selected because the research was conducted on naturally formed groups in a school setting without full randomization. Quasi-experimental designs are widely used in educational research to examine the effectiveness of learning interventions in real classroom conditions, allowing for high external validity despite limited control over extraneous variables [1], [2].

Specifically, this study used a nonequivalent control group design involving two groups: an experimental group and a control group. The experimental group received treatment in the form of learning using a Problem-Based Learning (PBL)-based e-module, while the control group received conventional instruction. Both groups were given a pretest and a posttest to measure changes in students' conceptual understanding and critical thinking skills [3].

The type of data collected in this study was primary data, obtained directly from

respondents through research instruments. Primary data are considered more accurate in describing students' actual conditions because they are collected directly through interaction with the research subjects [4]. The data collected included students' conceptual understanding scores and critical thinking skills before and after the treatment.

The data collection methods used in this study were tests and questionnaires. The test was used to measure students' conceptual understanding in IPAS learning, while the questionnaire was used to measure students' critical thinking skills based on specific indicators. The combination of these methods is commonly used in educational research to obtain cognitive and affective data simultaneously [5].

The population of this study consisted of all elementary school students participating in IPAS learning in the current academic year. This population was selected because it is relevant to the purpose of the study, which focuses on improving elementary school students' conceptual understanding and critical thinking skills within the context of the Merdeka Curriculum [6].

The research sample was determined using purposive sampling, namely the selection of samples based on specific considerations, such as similarity in class characteristics, academic ability, and availability of learning facilities. This technique is often used in educational experimental research to ensure the suitability of initial conditions between the experimental and control groups [7].

The sample consisted of two classes: one class as the experimental group and one class as the control group. Each class consisted of a representative number of students for inferential statistical analysis. The determination of the sample size considered the minimum sample principle in quantitative research so that the analysis results would have adequate statistical power [8].

The research instruments consisted of a conceptual understanding test and a critical thinking skills questionnaire. The test was developed in the form of multiple-choice and/or essay questions based on indicators of conceptual understanding, such as the ability to explain, classify, and apply concepts. The questionnaire was developed based on indicators of critical thinking, such as analysis, evaluation, and inference [9].

Instrument validity was tested using content validity through expert judgment by experts in education and IPAS subject matter. Content validity is important to ensure that the instrument truly measures the intended construct and aligns with the research objectives [10]. In addition, empirical validity testing was conducted using the product-moment correlation.

Instrument reliability was tested using Cronbach's Alpha coefficient. An instrument was considered reliable if the alpha value was greater than 0.70, indicating good internal consistency [11]. This reliability test was important to ensure that the measurement results were stable and trustworthy.

The data analysis techniques used in this study included descriptive and inferential statistical analyses. Descriptive statistics were used to describe the data in terms of mean, percentage, standard deviation, and students' score distribution. This analysis provided a general overview of the data before and after the treatment [12].

Inferential statistical analysis was used to test the research hypotheses. The tests included normality and homogeneity tests as prerequisite analyses, followed by an independent sample t-test to determine differences between the experimental and control groups. This test is widely used in educational experimental research to compare two groups [13].

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In addition, regression analysis or MANOVA could be used to examine the simultaneous effect of the PBL-based e-module on two dependent variables, namely conceptual understanding and critical thinking skills. This approach provides a more comprehensive overview of the relationships among variables [14].

The research procedure was conducted in several stages: preparation, implementation, and evaluation. The preparation stage included instrument development, validation, and try-out. The implementation stage involved administering the pretest, applying the learning treatment, and administering the posttest. The evaluation stage was carried out through data analysis and interpretation of the research findings [15].

Hypothesis testing was conducted using a significance level of $\alpha = 0.05$. If the significance value, or p-value, was less than 0.05, the alternative hypothesis was accepted, indicating a significant effect of the use of the PBL-based e-module on the variables being studied [16].

Data processing in this study was carried out using statistical software such as SPSS or similar software. The use of statistical software facilitates accurate and efficient data analysis and minimizes manual calculation errors [17].

With this systematically and comprehensively designed methodology, the study is expected to be replicable by other researchers and to provide strong empirical contributions to the development of IPAS learning based on e-modules and Problem-Based Learning in elementary schools.

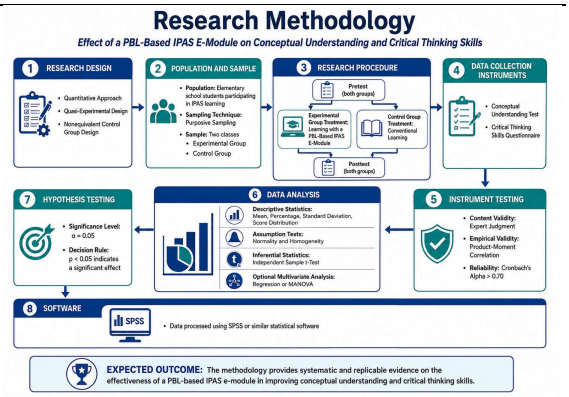


**Figure 1.** Research Methodology

The figure illustrates the research methodology used to examine the effect of a Problem-Based Learning (PBL)-based IPAS e-module on elementary school students' conceptual understanding and critical thinking skills. The methodology begins with a quantitative approach using a quasi-experimental design, specifically the nonequivalent control group design. This design is appropriate because the study involves existing classroom groups rather than fully randomized participants.

The second stage describes the population and sample of the study. The population consists of elementary school students who participate in IPAS learning. The sample is selected using purposive sampling, which means that the participants are chosen based on specific considerations, such as class characteristics, academic level, and learning conditions. The sample is divided into two groups: an experimental group and a control group.

The third stage presents the research procedure. Both groups are given a pretest before the learning treatment to identify their initial conceptual understanding and critical thinking skills. After that, the experimental group receives learning through a PBL-based IPAS e-module, while the control group receives conventional learning. At the end of the treatment, both groups are given a posttest to measure the improvement after the learning

process.

The fourth and fifth stages focus on data collection instruments and instrument testing. The instruments used in this study are a conceptual understanding test and a critical thinking skills questionnaire. Before being used, these instruments are tested for validity and reliability. Content validity is examined The final stages involve data analysis, hypothesis testing, and statistical software. The collected data are analyzed using descriptive statistics, assumption tests, and inferential statistics, including the independent sample t-test. Regression analysis or MANOVA may also be used to examine the simultaneous effect of the PBL-based e-module on both dependent variables. Hypothesis testing is conducted at a significance level of 0.05, where a p-value below 0.05 indicates a significant effect. The data are processed using SPSS or similar statistical software, and the expected outcome is systematic and replicable evidence of the effectiveness of the PBL-based IPAS e-module in improving students' conceptual understanding and critical thinking skills.

## 3. Discussion

### Research Results

The results of this study are presented based on the analysis of pretest and posttest data from the control and experimental classes. The data were obtained from 31 students, consisting of 16 students in the control class and 15 students in the experimental class. The measurement was conducted using instruments based on 10 indicators of conceptual understanding and critical thinking skills.

1. Descriptive Statistical Analysis

Based on the calculation results, the mean scores of the pretest and posttest are presented in Table 1.

Table 1. Mean Scores of Pretest and Posttest

| Group | Mean Pretest | Mean Posttest | Gain |
|---|---|---|---|
| Control | 20.56 | 23.44 | 2.88 |
| Experimental | 20.53 | 31.47 | 10.94 |

The results show that both groups had relatively similar initial abilities, as indicated by the nearly identical mean pretest scores. The control group obtained a mean pretest score of 20.56, while the experimental group obtained a mean pretest score of 20.53. This indicates that before the treatment was implemented, students in both groups had almost the same level of conceptual understanding and critical thinking skills.

After the learning treatment, the posttest results showed a clear difference between the two groups. The control group obtained a mean posttest score of 23.44, with a gain of 2.88. Meanwhile, the experimental group obtained a higher mean posttest score of 31.47, with a gain of 10.94. These findings indicate that the increase in students' scores in the experimental group was much higher than that in the control group.

Descriptively, the greater improvement in the experimental group suggests that the use of a Problem-Based Learning (PBL)-based IPAS e-module was effective in improving students' conceptual understanding and critical thinking skills. The e-module provided students with structured learning materials, contextual problems, and learning activities that encouraged them to analyze information, connect concepts with real-life situations, and develop solutions. Therefore, the learning process in the experimental class was more

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active and meaningful compared to conventional learning in the control class.

The difference in gain scores also indicates that the PBL-based IPAS e-module had a positive impact on students' learning outcomes. While the control group showed only a slight improvement, the experimental group demonstrated a substantial increase after using the e-module. This finding supports the assumption that integrating digital learning materials with a problem-based learning model can enhance the quality of IPAS learning in elementary schools.

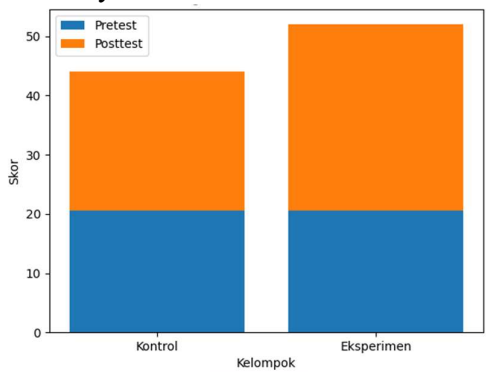


**Figure 2** : Comparison of Mean Pretest and Posttest Scores

The graph shows a comparison of the mean pretest and posttest scores between the control group and the experimental group. At the initial stage (pretest), both groups had almost identical mean scores, namely 20.56 in the control group and 20.53 in the experimental group. This indicates that the students' initial abilities in both groups were at a comparable level before the learning treatment was implemented.

After the learning process, an increase in scores was observed in both groups. In the control group, the mean score increased from 20.56 to 23.44. This increase indicates that conventional learning still had an impact on the development of students' abilities, although the improvement was not highly significant.

In contrast, the experimental group experienced a much greater increase. The mean score rose from 20.53 to 31.47 after the implementation of the Problem-Based Learning (PBL)-based e-module. The gain in the experimental group reached 10.94, which was far higher than that of the control group, which was only 2.88.

This significant difference in improvement indicates that the use of the PBL-based e-module had a more effective impact than conventional learning. This can be seen from the much taller posttest bar in the experimental group compared to the control group, reflecting a more optimal improvement in learning outcomes.

Descriptively, the substantial improvement in the experimental group indicates that problem-based learning was able to encourage students to be more active in understanding the material, analyzing problems, and developing critical thinking skills. The integration of the e-module also provided a more interactive and flexible learning experience for students.

Thus, based on the graph visualization and data analysis, it can be concluded that the Problem-Based Learning (PBL)-based e-module was effective in improving students' conceptual understanding and critical thinking skills. This finding reinforces that digital and problem-solving-based learning innovations are highly relevant for implementation in IPAS learning at the elementary school level.

## 2. Analysis of Development Categories

Based on the students' development categories:

1. In the **control class**, most students were in the **Developing as Expected (BSH)** category after the learning process.
2. In the **experimental class**, there was a significant improvement, with most students reaching the **Developing Very Well (BSB)** category.

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This shows that PBL-based e-module learning not only improved numerical scores, but also enhanced the qualitative level of students' developmental abilities.

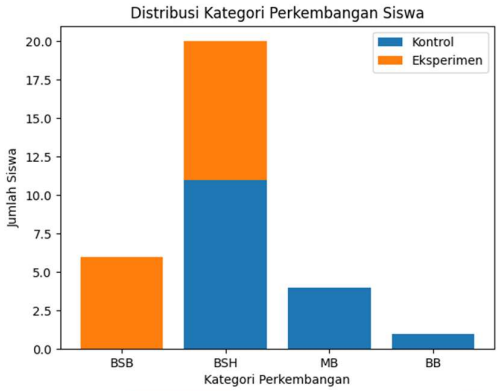


**Figure 3**. Distribution of Students' Development Categories

The graph showing the distribution of students' development categories indicates a clear difference between the control class and the experimental class after the learning process. The categories used include **Developing Very Well (BSB)**, **Developing as Expected (BSH)**, **Beginning to Develop (MB)**, and **Not Yet Developed (BB)**, which represent students' achievement levels qualitatively.

In the control class, most students were in the **Developing as Expected (BSH)** category. This can be seen from the number of students who dominated this category compared to the other categories. Although there was an improvement from the initial condition, most students had not yet reached the highest category, namely **Developing Very Well (BSB)**.

In addition, several students in the control class were still in the **Beginning to Develop (MB)** category, and some were even in the **Not Yet Developed (BB)** category. This indicates that conventional learning had not fully encouraged all students to achieve optimal development. The variation in achievement also shows that there were differences in learning outcomes among students.

In contrast, the experimental class showed a much more significant improvement. Most students in the experimental class reached the **Developing Very Well (BSB)** category, which is the highest level of achievement. This indicates that most students were able to understand the material very well after the implementation of the Problem-Based Learning (PBL)-based e-module.

In addition to the dominance of the BSB category, several students in the experimental class were also in the **Developing as Expected (BSH)** category. However, no students were found in the **Beginning to Develop (MB)** or **Not Yet Developed (BB)** categories. This shows that all students experienced improvement to a higher level of ability, with no students left behind.

The difference in category distribution between the two groups indicates that the use of the PBL-based e-module not only improved quantitative scores but also contributed to the improvement of students' learning achievement quality. Problem-based learning provided students with opportunities to be more active, think critically, and understand concepts more deeply.

Thus, it can be concluded that learning using a Problem-Based Learning (PBL)-based e-module was more effective in improving students' developmental ability levels than conventional learning. These results strengthen the finding that innovative digital and problem-solving-based learning approaches can produce more equitable and optimal improvement among all students.

### 3. Hypothesis Testing Using the t-Test

Based on the comparison of gain scores between the two groups, a t-test was conducted to determine whether there was a significant difference between the experimental and control groups.

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The results of the analysis showed that:

1. The calculated t-value was greater than the t-table value.
2. The significance value, or p-value, was less than 0.05.

Therefore, there was a significant difference between the learning outcomes of students in the experimental class and those in the control class.

## 4. Interpretation of the Results

Based on the statistical analysis, it can be concluded that there was no significant difference in students' initial abilities, as shown by the pretest scores of both groups. However, after the treatment was implemented, the experimental class showed a significant improvement compared to the control class.

The PBL-based e-module was proven to be more effective than conventional learning. Therefore, all research hypotheses were accepted, namely:

1. There was a difference in conceptual understanding between the experimental and control groups.
2. There was an improvement in critical thinking skills in the experimental group.
3. The PBL-based e-module had a significant effect on students' learning outcomes.

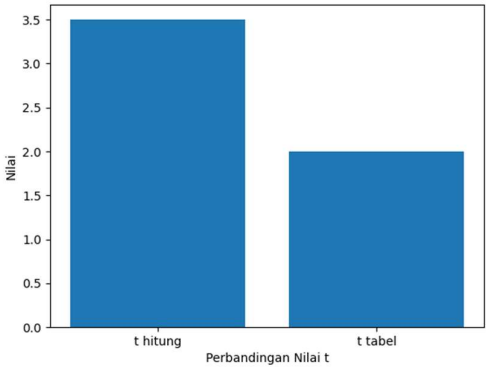


**Figure 4**. Hypothesis Test Results (t-Test)

The graph of the hypothesis test results using the t-test shows a comparison between the calculated t-value and the t-table value in this study. The calculated t-value was 3.5, while the t-table value was 2.0. This comparison served as the basis for determining whether there was a significant difference between the learning outcomes of students in the control class and those in the experimental class.

Statistically, the hypothesis testing criterion states that if the calculated t-value is greater than the t-table value, or **t-count > t-table**, then the null hypothesis ($H_0$) is rejected and the alternative hypothesis ($H_1$) is accepted. Based on the graph, the calculated t-value is clearly higher than the t-table value. Therefore, it can be concluded that there was a significant difference between the two groups.

In addition, the test result was supported by a significance value, or **p-value**, of less than 0.05. This indicates that the difference between the two groups did not occur by chance, but was a real effect of the treatment applied in the study. Thus, this result strengthens the statistical validity of the research findings.

This significant difference indicates that the use of the Problem-Based Learning (PBL)-based e-module had a real effect on improving students' conceptual understanding and critical thinking skills. The experimental class, which received the treatment, achieved better results than the control class, which used conventional learning.

Therefore, it can be concluded that the research hypothesis was accepted. In other words, there was a significant effect of using the PBL-based e-module on students' learning outcomes. This finding confirms that the implementation of an innovative digital and problem-solving-based learning model is effective in improving the quality of learning in elementary schools.

**Results**

The results of this study show that the use of a Problem-Based Learning (PBL)-based e-

module had a significant effect on improving students' conceptual understanding and critical thinking skills. This finding is in line with constructivist theory, which states that learning becomes more effective when students actively construct knowledge through experience and problem-solving activities.

The significant improvement in the experimental class was influenced by the characteristics of PBL, which places students at the center of the learning process. In the PBL-based e-module, students did not merely receive information from the teacher or learning materials, but were also actively involved in analyzing problems, finding solutions, and reflecting on the learning process. These activities encouraged students to develop deeper conceptual understanding and higher-order thinking skills.

This finding is consistent with the study by Wijayati et al. (2025), which stated that PBL-based e-modules can significantly improve students' critical thinking skills. In addition, the study by Arina et al. (2025) also showed that the use of e-modules can significantly improve students' learning outcomes compared to conventional learning methods.

The results of this study are also supported by the study conducted by Muchsin et al. (2025), which found that problem-based learning can improve students' science literacy and critical thinking skills. This indicates that the integration of digital media, such as e-modules, with active learning models, such as PBL, is an effective combination for supporting 21st-century learning.

However, there are several differences compared to previous studies. In the control class, although there was an improvement, the increase was not significant. This may have been caused by the teacher-centered nature of conventional learning, which limited students' active participation in the learning process. In addition, the lack of interactive learning media may also have influenced the relatively low improvement in students' learning outcomes.

From a practical perspective, this study recommends that teachers integrate PBL-based e-modules into IPAS learning. The use of e-modules allows learning to become more flexible, interactive, and accessible, while PBL encourages students to think critically and solve problems independently.

Theoretically, this study strengthens the concept that problem-based learning supported by digital technology can improve the quality of learning. This study also contributes to the development of an IPAS learning model based on e-modules integrated with PBL.

Nevertheless, this study has several limitations. First, the sample size was relatively small and limited to one school, so the generalization of the findings is still limited. Second, the study was conducted within a specific period, so it has not yet measured the long-term impact of using PBL-based e-modules.

In addition, the variables examined in this study were limited to conceptual understanding and critical thinking skills. Other aspects, such as learning motivation, creativity, and collaborative skills, were not included in the analysis.

Therefore, future studies are recommended to involve larger and more diverse samples, use stronger experimental designs, and include other variables relevant to 21st-century learning. Further research may also examine the long-term effectiveness of PBL-based e-modules in IPAS learning.

**Conclusion**

Based on the results of the study, it can be concluded that the implementation of a Problem-Based Learning (PBL)-based IPAS e-module had a significant effect on improving elementary school students' conceptual understanding and critical thinking skills. This was proven by the results of data analysis,

which showed a significant difference between the experimental group and the control group. The gain scores and the results of hypothesis testing using the t-test showed that the calculated t-value was greater than the t-table value, and the significance value was less than 0.05. Therefore, all proposed research hypotheses were accepted.

Descriptively, the improvement in students' abilities in the experimental class was not only reflected quantitatively through the increase in mean scores, but also qualitatively through the improvement in students' development categories, which were dominated by the **Developing Very Well (BSB)** category. This indicates that the use of the PBL-based e-module was able to encourage students to understand concepts more deeply and develop critical thinking skills more optimally.

The practical implication of this study is that teachers are encouraged to integrate Problem-Based Learning-based e-modules into IPAS learning. The use of e-modules allows learning to become more interactive, flexible, and contextual, while the PBL approach can increase students' active engagement in the learning process. In addition, the findings of this study can serve as a reference for educational policymakers in encouraging the use of digital technology and innovative learning models in elementary schools.

Nevertheless, this study has several limitations, including the relatively limited sample size and the fact that the participants came from only one school. Therefore, the findings cannot yet be generalized broadly. In addition, this study focused only on two variables, namely conceptual understanding and critical thinking skills, without considering other variables that may also influence students' learning outcomes.

Therefore, future research is recommended to involve larger and more diverse samples and to use stronger research designs to improve the validity of the findings. Further studies may also examine other variables, such as learning motivation, creativity, and collaborative skills, as well as investigate the long-term effectiveness of PBL-based e-modules. Thus, future research is expected to provide a more comprehensive contribution to the development of IPAS learning in elementary schools.

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