



Needs Analysis for Developing PBL-Based E-Modules on Alternative Energy to Improve High School Students' Critical Thinking Ability

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ABSTRACT

Technological and scientific progress is a characteristic of the 21st century that requires students to think creatively, communicate, critically and also collaborate. This study aims to perform a requirements analysis in developing E-Modules based on Problem Based Learning on alternative energy material and its use to Enhancing students' critical thinking abilities in high school. The conclusion of this research show five result from the needs analysis, namely: (1) The utilization of ICT in education with a score of 94 in the very good category. (2) student characteristics are good with a value of 71.80. (3) Implementation of learning objectives by teachers as observed from learning outcomes. objective flow of one physics teacher are in the sufficient category. (4) Learning arrangements implemented by teachers seen from the teaching module of one teacher are in the sufficient category. (5) analysis of students' critical thinking skills. Data were obtained from 21 grade XI students with an average of 22.77 in the less category.

Keywords: ICT-based teaching materials, E-Modules, Critical Thinking, Problem Based Learning.



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I. INTRODUCTION

The progress of IPTEK in the 21st century is developing very quickly and has significantly affected various areas of life, including education [1]. These developments require the world of education to adapt to changing times by utilizing technology during the process of learning. The integration of Communication and information technology is a crucial aspect in improving the quality of learning and supporting a more effective and relevant educational process [2].

In 21st century education, students are required to possess various skills that can help them face global challenges. These skills are known as 21st century skills known as the 4Cs, including critical thinking skills, communication, creativity, and collaboration [3]. These four skills are an important foundation in forming individuals who are able to adapt, think innovatively, and actively participate in community life.

One of the skills that plays a crucial role in 21st-century learning is critical thinking. This ability enables pupils to evaluate data in depth, pupils to evaluate data points of view, and draw logical and systematic conclusions [4]. Therefore, Developing critical thinking skills is an important aspect to undertake primary goals of the learning process in schools. Mastery of these 21st-century skills is crucial so that students can adapt to ever-evolving demands of the workplace and social life. Among the 4C skills, Critical thinking plays an important role in the educational process so that children can adapt to new environments. This ability enables students to analyze problems in depth, evaluate information, and draw logical and systematic conclusions [5].

Critical thinking ability is an important aspect of the learning process. This ability is not limited to critical activity, but also includes the ability to evaluate information and generate rational solutions. Critical thinking encourages students to consider and identify various alternative solutions based on available facts. Furthermore, this ability involves the process of systematic analysis, reflection, and assessment of information in an effort to solve problems [6]. Therefore, a learning model is needed that can support the development of students' critical thinking skills.

Problem-Based Learning a learning approach that creates challenges, is one that can be applied the basis of the learning process. PBL has been proven effective in developing Students' capacity for problem-solving. In physics learning, problem solving involves not only computational manipulation of formulas, but it also entails

applying principles, finding pertinent concepts, and using logical reasoning via a variety of analysis steps.[7]. To support the effectiveness of implementing the PBL model in physics learning, teaching materials are needed that are designed based on the characteristics of the model.

Printed learning materials play a role in the educational process, serving as a guide for students to achieve learning objectives. Printed learning materials, including textbooks and modules, have been used as the main source in the learning process. These teaching materials act as a manual for pupils in understanding the material systematically and structured. However, alongside scientific and technological advancements, printed teaching materials have limitations in meeting the 21st-century educational needs. These limitations include low levels of interactivity, lack of visual appeal, and less than optimal in stimulating students' critical thinking skills [8]. This indicates the need for innovation in digital-based instructional resources that are more dynamic and capable of support students' independent learning.

Electronic modules (e-modules) are digital teaching materials systematically designed to include materials, learning activities, and evaluations that enable students to learn independently. They are written using simple, structured language, facilitating pupils' comprehension of the subject matter without relying entirely on the teacher[9]. However, the development of e-modules with specific learning models, particularly PBL-based ones, is still limited.

Based on a preliminary study conducted at Muhammadiyah 3 Senior High School in Padang, Students' critical thinking abilities are still comparatively low, it was discovered. This is due to the learning process not being fully student-centered and the lack of contextual problem presentation in the lessons. This condition impacts students' low ability to analyze, evaluate, and solve problems, particularly in the topic of alternative energy and its utilization.

Based on these problems, there is a gap between ideal conditions and actual conditions, namely the unavailability of instructional resources in the form PBL-based e-modules that can support the development of students' critical thinking skills. Therefore, this study aims to conduct a needs analysis in the development of PBL-based e-modules on alternative energy material as an effort to enhance the capacity for critical thought of high school students. This research is expected to contribute to the development of innovative teaching materials that are in line with the requirements of learning in the twenty-first century.

II. METHOD

This study uses a quantitative descriptive method that aims to describe conditions factually and accurately based on the numerical data obtained [10]. This approach was chosen in light of the studies objective, namely to identify the need for developing e-modules based on Problem-Based Learning (PBL) to enhance pupils' capacity for critical thought. This approach allows researchers to collect, process, and analyze data systematically to get a whole image of the phenomenon being studied [11]. Research conclusions are drawn based on the results of data analysis processed using descriptive statistics [12].

The needs analysis in this study focused on several aspects, namely Information and communication technology (ICT) utilization, student characteristics, learning objectives, learning arrangements, the use of teaching materials by teachers, and students' critical thinking skills. The study was conducted at SMA Muhammadiyah 3 Padang with research subjects consisting of 1 physics teacher and 21 grade XI students. Purposive sampling was the method employed., namely the selection of samples according to specific considerations pertinent to the goals of the study.

Data collection was conducted through questionnaires, observations, and tests. The questionnaires consisted of teacher and student questionnaires. The teacher questionnaire was used to obtain information on ICT utilization and learning planning and organization, while the student questionnaire was used to identify student characteristics. Observations were made on the use of teaching materials by teachers and student activities in completing physics assignments. Tests were used to assess students' critical thinking skills.

Data analysis was carried out using descriptive statistical techniques. The data obtained were processed and presented in tables and graphs to provide a clear picture of the needs analysis results. The scores obtained were then interpreted based on specific criteria to determine the categories of the needs analysis results. The results of the needs analysis score interpretation categories are shown in Table 1.

Table 1. Category of Value Interpretation

Intervals	Category
81 – 100	Very good
61 – 80	Good
41 – 60	Fair
21 – 40	Poor
0 – 20	Fail

(Source : Ref [13])

III. RESULTS AND DISCUSSION

Results

The results of a preliminary study on the use of ICT in physics learning were obtained through a questionnaire given to physics teachers and eleventh grade students. The analysis results showed that the average use of ICT by teachers was 64, categorized as good, while students obtained an average of 94, categorized as very good. The analysis of ICT use by teachers includes four components, namely the use of ICT in learning (PB), the use of ICT in teaching materials (BA), the use of ICT in learning media (MP), and the use of ICT in evaluation (PN). The complete results are presented in Figure 1.

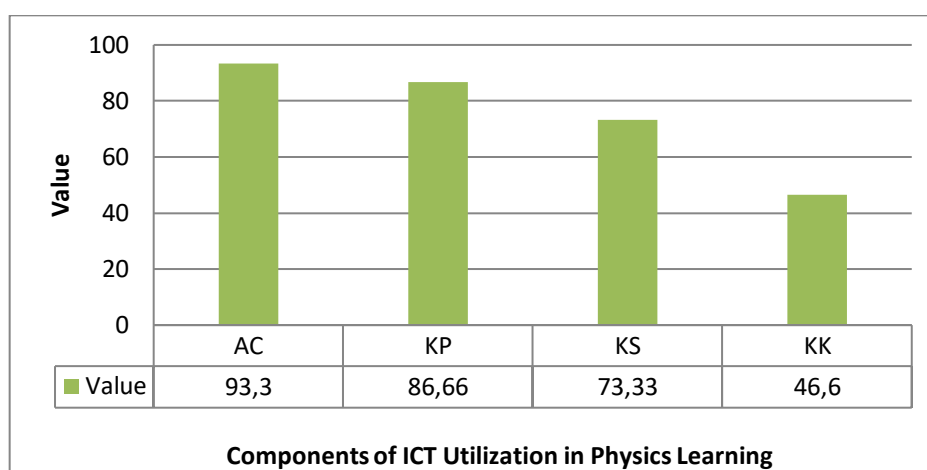


Figure 1. Results of Analysis of the Use of ICT in Physics Learning

Based on Figure 1, ICT use in physics education shows variation in each component. The ICT utilization in learning (PB) component received the highest score of 84, indicating that ICT has been utilized in learning activities such as giving assignments, searching for references, and communicating. The use of ICT in teaching materials (BA) and evaluation (PN) each received a score of 67, categorized as good.

The utilization of ICT in learning media (MP) received the lowest score, at 50, indicating that ICT-based media use is still suboptimal. This condition indicates that ICT utilization is more dominant in administrative and support aspects, but has not been utilized optimally as an interactive learning medium. This could be due to the limited use of digital media in learning or the lack of development of ICT-based teaching materials. Therefore, the development of more interactive ICT-based learning media is needed to improve learning effectiveness.

The second research result relates to student characteristics obtained through a questionnaire administered to 21 eleventh-grade students of SMA Muhammadiyah 3 Padang. Based on the analysis, the average score was 71.80, categorized as good. Student characteristics were analyzed based on several components, namely learning motivation (MB), learning style (GB), interest (MN), attitude (S), and thinking ability (KB). The results of the analysis of each component are presented in Figure 2.

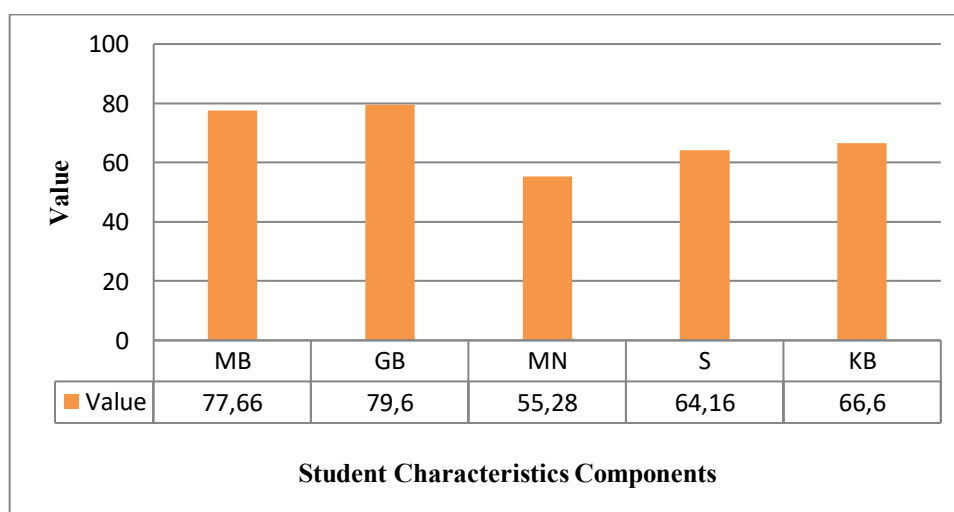


Figure 2. Results of Student Characteristics Analysis

Based on Figure 2, student characteristics show variations in each component. Learning style (GB) obtained the highest score of 79.6, followed by learning motivation (MB) at 77.66, indicating that students have good readiness and interest in participating in physics learning. Meanwhile, interest (MN), attitude (S), and thinking ability (KB) obtained scores of 55.28; 64.16; and 66.6, respectively. The lowest score was found in the learning interest (MN) component, indicating that students' interest in physics learning is still not optimal. In addition, thinking ability (KB) which is in the good but not yet high category indicates that students still need to be encouraged to develop deeper thinking skills. This condition may be brought on by the absence of variety in learning models and teaching materials that can stimulate student activity and thinking. Therefore, the development of more interactive learning, such as utilizing problem-based learning-based e-modules, is needed to increase student interest and thinking skills.

The third research result relates to the analysis of learning objectives (TP) conducted through document analysis. The components of learning objectives include audience (AC), knowledge ability (KP), attitude ability (KS), skill ability (KK), condition (CD), and degree (DR). The audience component refers to the learning subject, namely the student, while the ability component includes the knowledge, attitudes, and skills expected to be achieved. The condition component relates to the conditions or learning situation, and the degree indicates the level of success that must be achieved. The results of the analysis of each component are presented in Figure 3.

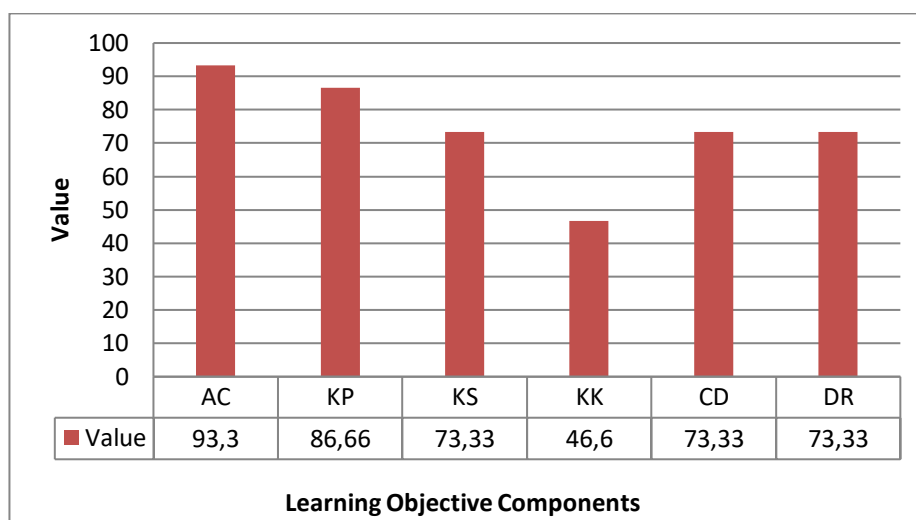


Figure 3. Results of Learning Objective Analysis

Based on Figure 3, the learning objectives component scores ranged from 46.6 to 93.3. The audience component (AC) received the highest score of 93.3, categorized as very high, indicating that the learning objectives were clearly formulated and focused on students. The knowledge and skills component (KP) also received a high score of 86.6, indicating appropriate use of operational verbs.

Meanwhile, the attitude and skills components (KS), condition (CD), and degree (DR) each received a score of 73.33, categorized as high, but were not optimal because some learning objectives did not fully state the conditions and success criteria. The lowest score was found in the skills component (KK) with 46.6, categorized as sufficient. This indicates that the skills aspect has not been clearly formulated in the learning objectives.

This situation indicates that the formulation of learning objectives still focuses more on knowledge than skills. As a result, development of critical thinking skills and other higher-order thinking skills, has not been optimally facilitated. Therefore, the formulation of more comprehensive learning objectives is needed, integrated with learning models that help enhance pupils' critical thinking abilities.

The fourth research finding relates to the analysis of teachers' needs for learning modules structured based on the Learning Objective Flow (ATP). The developed teaching modules contain a learning structure consisting of introductory activities (KPD), core activities (KI), and closing activities (KPN), and implement The model of Problem-Based Learning (PBL). An analysis of the learning structure implemented by teachers is presented in Figure 4.

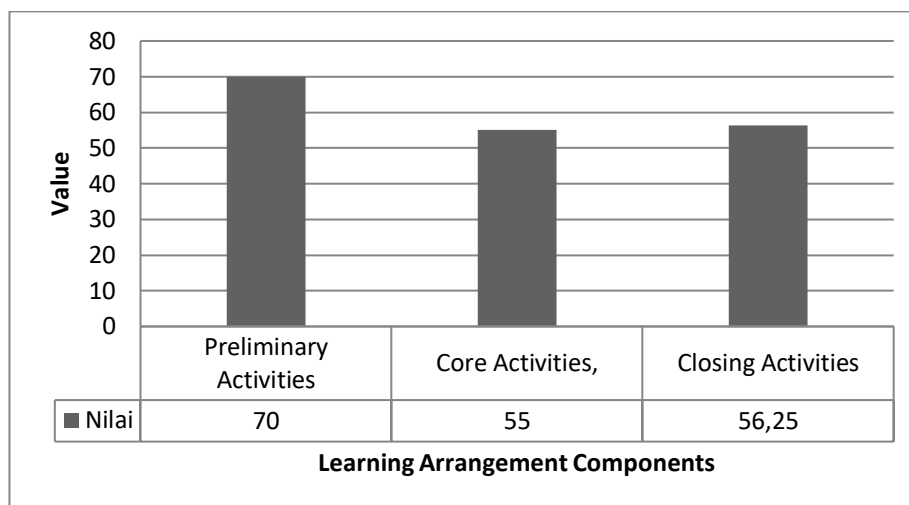


Figure 4. Analysis of Learning Settings

Based on Figure 4, the learning structure in the teaching module shows variation at each stage. The preliminary activity (KPD) received a score of 70, categorized as good, demonstrating that the teacher initiated the lesson by providing stimulus in the form of contextual phenomena. Meanwhile, the core activity (KI) received a score of 55, categorized as adequate, demonstrating that the implementation of PBL steps was not yet fully optimized, particularly in facilitating students to formulate hypotheses, collect, and process data systematically.

The final study obtained score of 56.25, categorized as adequate, demonstrating that the teacher guided pupils to choose the learning objectives, but did not optimally reflect on and assess the process of solving an issue. This condition indicates that the implementation of PBL in the teaching module has not been fully implemented at each stage of the learning. Consequently, the development of pupils' capacity for critical thought has not been optimally facilitated. Therefore, the development of a more structured learning module that aligns with PBL syntax is needed to support active student engagement in the learning process.

The main research findings relate to critical thinking skills, as determined by a test administered to 21 grade XI Phase F students. The test instrument was used to measure students' critical thinking skills in physics learning. The results of the data analysis regarding students' critical thinking skills can be seen in table 2 below.

Table 2. Results of Analysis of Students' Critical Thinking Skills

Statistical Parameters	Critical Thinking Skills
Number of students	21
Mean	22.77
Mode	31.25
Median	21.87
Minimum	12.50
Maximum	37.50

Based on Table 2, students' critical thinking skills are still relatively low, with an average score of 22.77. The minimum and maximum scores of 12.50 and 37.50, respectively, indicate that most students have not yet achieved optimal critical thinking skills. This suggests that pupils still have difficulty analyzing problems, evaluating information, and coming to rational conclusions.

This Low capacity for critical thought is believed to be related to the suboptimal implementation of learning that emphasizes problem-solving activities and active student involvement. Although student characteristics such as motivation, interest, and attitude are in the good category, these do not directly encourage of critical thinking abilities. Therefore, more targeted learning strategies are needed, such as the application of the Problem-Based Learning (PBL) paradigm backed by e-modules, to guide students in developing more in-depth critical thinking skills.

Discussion

The research findings indicate that the development of Problem-Based Learning (PBL)-based e-modules is based on the results of a needs analysis that includes the use of ICT whilst studying physics. The analysis's findings demonstrate that the application of ICT is in the good category, indicating the readiness of the school environment to support the integration of technology in learning. However, the use of ICT is not yet fully optimal, especially in supporting interactive and student-centered learning activities. This condition indicates that the use of ICT still needs to be directed towards the development of teaching materials that can encourage active student involvement. Appropriate use of ICT plays a crucial role in supporting 21st-century learning, so The development of PBL-based electronic modules is a viable alternative to improve classroom teaching

standards[14].

Research results related to critical thinking skills indicate that students' abilities are still in the low category across all indicators. The Strategies and Tactics indicator scored 23.8%, Basic Clarification 22.02%, Bases for a Decision 25.0%, Inference 19.04%, and Advanced Clarification 26.1%. The low achievement in each indicator indicates that students still experience difficulties in formulating problem-solving strategies, providing basic explanations, making decisions, and drawing logical conclusions. This condition indicates that the ongoing learning process has not fully trained higher-order thinking skills. Therefore, it is essential to implement learning models that emphasize problem-solving and active student involvement, such as PBL supported by e-modules, to develop critical thinking skills more optimally.

The study's findings show that pupils' critical thinking skills in physics Learning is still in the low range[15]. This finding is in line with previous research which stated that low critical thinking skills are influenced by students' learning habits which tend to be passive and dependent on teacher explanations [16]. In addition, students are not yet accustomed to linking the concepts learned with real situations and are less trained in solving problems independently [17]. This condition indicates that the ongoing learning process has not fully encouraged higher-order thinking activities. Theoretically, critical thinking skills develop through the active involvement of pupils in evaluating, evaluating, and resolving issues, so a learning strategy is needed that can facilitate this process systematically.

Another finding indicates that the application of PBL, or problem-based learning model in learning has not had an optimal impact on the growth of pupils' critical thinking skills. Although PBL has been implemented, its implementation has not fully followed a systematic syntax, especially in the stages of hypothesis formulation, data collection, and solution development. This results in limited student engagement in the learning process, resulting in underdevelopment of critical thinking skills. Furthermore, differences in student learning styles, particularly the dominance of visual and auditory styles, have not been fully accommodated in learning. This mismatch between the learning model, student characteristics, and teaching materials is one factor influencing low critical thinking skills. Consequently, it is essential to create instructional resources that are integrated with PBL syntax and are able to adapt to student characteristics, such as e-modules that combine visual and interactive elements, so as to optimally enhance students' critical thinking abilities and engagement.

The fourth real condition relates to students' difficulties in learning alternative energy and its utilization. The findings indicate that students are unable to properly understand the concept of energy sources, are less able to provide relevant examples, and have difficulty summarizing the information presented [18]. Furthermore, the material is considered extensive and complex, making it difficult for students to organize their understanding comprehensively. This is reflected in the limited teaching materials in the independent curriculum, as indicated by a score of 65.00 [19].

The fifth real condition relates to low student learning outcomes. Mid-semester assessment (PTS) data shows that the average score for 11th-grade students is 40.03, It falls into the category of poor. This low learning outcome shows that students' conceptual mastery is not optimal. This condition is inconsistent with students' generally good characteristics, such as motivation, interests, learning styles, and attitudes. This discrepancy indicates other factors influencing learning outcomes, such as suboptimal learning strategies, limited teaching materials, and the less than optimal implementation of learning models that actively engage students. Therefore, learning innovations are needed that can integrate student characteristics with appropriate teaching models and materials, thereby improving students' conceptual understanding and critical thinking skills.

IV. CONCLUSION

Based on the needs analysis, several key conclusions that came from this study. The use of ICT in physics learning is considered good, but has not been utilized optimally in all aspects of learning. Student characteristics are good, but not aligned with critical thinking skills, which are still quite low. Furthermore, the implementation of the PBL (Problem-Based Learning) approach in learning has not been fully implemented according to the expected syntax.

These results show a discrepancy between student potential, the learning process, and the outcomes achieved, particularly in the development of critical thinking skills. Therefore, the development of PBL-based e-modules for alternative energy is crucial to provide more interactive, contextual teaching materials that encourage active student engagement in learning.

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