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Design of Electronic Worksheets Integrated with Problem Based Learning and Ethnoscience to Improve Critical Thinking Skills of High School Students

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ABSTRACT

The rapid advancements in science and technology in the 21st century necessitate significant improvements in the quality of education, especially in fostering students' critical thinking skills. These skills are crucial in the study of physics, as they encompass logical reasoning that can be substantiated. However, current assessments reveal that students' critical thinking abilities are notably lacking, with an average test score of only 46. 78, categorizing them as low performers. This shortfall can largely be attributed to passive learning methods and teaching materials that fail to align with students' learning styles. To tackle this issue, it is essential to develop teaching materials that promote critical thinking. One promising approach is the creation of electronic-based student worksheets that incorporate the Problem-Based Learning (PBL) model alongside an ethnoscience perspective. The PBL model encourages students to actively engage in analyzing problems systematically, while the ethnoscience approach integrates local wisdom into the learning process, making it more relevant and meaningful. This innovative combination aims to transform E-Student Worksheets into a powerful tool for enhancing student engagement and boosting critical thinking skills.

INTRODUCTION

In the 21 st century, science and technology (IPTEK) have advanced rapidly. This progress has impacted various aspects of life, including the field of education (Yulanda & Putra, 2024). 21st century education is education based on science and technology. The 21 st century education demands that students possess critical thinking skills, which are essential for tackling global challenges (Samadun & Dwikoranto, 2022). This ability involves interpretation, analysis, evaluation, explanation, sequencing, questioning, and decision making (Jamil et al, 2024). Thinking is a mental process in asking questions and answering in connecting knowledge appropriately (Lismayani et al., 2017). Critical thinking skills can be enhanced through physics learning, as it emphasizes direct experiences and student engagement to facilitate a deeper understanding (Yeritia et al., 2017).

In learning physics, students do not only know and remember but must also be able to learn how to work, understand concepts and make connections between one concept and another so that a good discovery process is created. (Samsul Anuar, 2024). Teachers must be able to help students develop their critical thinking abilities. Teaching materials must be prepared before physics instruction can begin. The teaching and learning process will take place actively, efficiently, creatively, interestingly and pleasantly if supported by the availability of teaching materials. (Diana & Sofi Makiyah, 2021). An E-Student Worksheet is one of the teaching materials that can be utilized. Concept understanding improves when students follow the structured activity steps provided in the worksheet (Wahyuni et al., 2021).

Students critical thinking abilities are still lacking in practice. The average result on a critical thinking test that included questions based on Ennis's five indicators was 46.78, falling into the bottom range. Because they participate passively in their education, students struggle to understand physics topics. Adhelacahya et al., 2023, which emphasizes that teachers continue to control the learning process, is in line with this finding. Furthermore, the teaching resources utilized are restricted to textbooks and have not been modified to take into account the various learning preferences of the pupils.

One factor contributing to students' low critical thinking skills is conventional learning, where teachers play a more active role in class, making students less engaged (Shofiyatul et al., 2021). Teaching resources that promote critical thinking are required to address this problem. Creating an E-Student Worksheet that combines ethnoscience and the Problem-Based Learning (PBL) paradigm is one potential remedy. From recognizing problems to coming up with solutions, the PBL approach actively encourages students to participate in group-based problem analysis (Rerung et al., 2017). Which aligns with the development of critical thinking skills (Sianturi et al., 2018). Ethnoscience, on the other hand, refers to the knowledge possessed by a nation or a specific ethnic or social group (Ahmad Fahrudin & Eka Maryam, 2022). Integrating problem based learning with local wisdom fosters student initiative, independence, and creativity in addressing challenges (Nuzula & Sudibyo, 2022).

The use of Electronic Worksheets in learning allows students to access instructional materials interactively and flexibly, thereby enhancing their engagement and independent understanding of concepts (Munawaroh, 2024). The Problem Based Learning (PBL) model encourages students to actively find solutions to real world problems, thereby fostering critical thinking, collaboration, and problem-solving skills (Arends.,2012). The integration of Ethnoscience in learning helps students connect scientific concepts with local wisdom, making the learning process more contextual and meaningful (Pabri et al., 2022). By combining e-worksheets, problem based learning (PBL), and ethnoscience, the learning process not only facilitates theoretical understanding but also develops practical skills and cultural values. This approach is believed to increase students' motivation to learn and analytical problem-solving skills. Furthermore, the use of digital media facilitates real-time progress monitoring and evaluation of learning outcomes. Overall, the combination of these three solutions creates innovative, interactive, and relevant learning experiences for students' daily lives.

The development of an electronic student worksheet that incorporates It is believed that ethnoscience and problem-based learning (PBL) can help students overcome their lack of critical thinking abilities in physics, especially in kinematics. Its application is also anticipated to produce a more dynamic, efficient, and captivating learning environment. The development of an Electronic Student Worksheet (E-LKPD) that incorporates ethnoscience and the Problem-Based Learning (PBL) model is believed to help students overcome their lack of critical thinking skills in learning physics, particularly in the topic of kinematics. Ethnoscience provides cultural and contextual elements that make learning more meaningful and relevant to students' daily experiences. Meanwhile, the PBL approach actively engages students in identifying and solving real-world problems, encouraging collaboration and independent thinking. Through this integration, students are expected to become more involved in the learning process and develop higher-order thinking skills. Therefore, this research aims to develop and produce an ethnoscience based E-student worksheet using the PBL model to enhance students' critical thinking skills in physics, especially in kinematics. It is also anticipated that the implementation of this E-LKPD will create a more dynamic, efficient, and engaging learning environment.

METHODS

This research employs a development research design. The method is implemented to guide the process of product creation and to identify the results of the developed product (Sugiyono, 2013). In this study, the product developed is an Electronic Student Worksheet (E-LKPD) that integrates the Problem-Based Learning (PBL) model with an ethnoscience approach. The integration aims to create a learning resource that connects scientific concepts with students' cultural contexts. Through this design, the research not only focuses on developing the product but also on assessing its quality and effectiveness. Therefore, this development research is expected to produce a valid, practical, and effective E-LKPD for learning motion kinematics in physics.

Thiagarajan's 4D model served as the basis for the development model employed in this investigation. The four steps of the 4D model are Definition, Design, Development, and Dissemination, according to Thiagarajan (1974).In 2022, (Herawati et al., 2022). Nevertheless, this study is restricted to the validation stage of development.

The instruments used in this study consisted of the instruments used in the form of needs analysis sheets, critical thinking ability essay questions referring to the Ennis indicators. and validation sheets. Validity analysis was carried out on a Likert scale with a score of 1 to 5.

Table 1. Validity statement weighting

Likert Scale	criteria
5	Strongly agree
4	Agree
3	Neutral
2	Don't agree
1	Strongly disagree

(Riduwan & Sunarto, 2012)

The research scale uses a Likert Scale from a score of 1-5. The validator's assessment uses the validity index proposed by Riduwan & Sunarto. Furthermore, the results of the questionnaire were then analyzed using the equation:

$$vs = \frac{Tse}{Tsh} \times 100\%$$

Information:

Vs = Validity percentage

TSe = Total empirical score

TSh = Maximum or ideal total score

Providing validity assessment with criteria as stated by Riduwan (2012).

Table 2. Validity criteria

Percentage (%)	criteria
81-100	Very valid
61-80	Valid
41-60	Quite valid
21-40	Less valid
0-20	Invalid

(Riduwan & Sunarto 2012)

RESULTS AND DISCUSSION

Results

The study product is an E-Student Worksheet that enhances student critical thinking skills, especially in the domain of motion kinematics, by fusing ethnoscience and problem-based learning. This research utilizes the 4D development model, which has multiple phases, specifically:

Definition stage

The definition stage is carried out in five steps, namely initial and final analysis, student analysis, task analysis, concept analysis, and learning objective analysis. This stage aims to identify problems and needs that form the basis for developing an E-LKPD integrated with Problem-Based Learning (PBL) and ethnoscience. The initial and final analyses are conducted to determine the current learning conditions and the expected outcomes after product development. The student analysis aims to understand students' characteristics, abilities, and learning needs. Furthermore, the task and concept analyses are conducted to determine the content and learning activities relevant to the learning objectives. The results of all these analyses serve as a reference in designing an E-LKPD that is contextual, engaging, and capable of enhancing students' critical thinking skills in physics learning.

In the initial-final analysis was conducted to determine the problems in physics learning. In the initial-final analysis it was found that 93% of students stated that they had never used E-student worksheet in learning. The problem encountered in the field is that teachers teach the material textually, meaning that teachers only distribute material according to the available books. However, with a learning approach that is still textual, students do not get an active and in-depth learning experience according to the demands of learning outcomes.

The critical thinking score for physics, which is 46.79, is known to remain low in student analysis. These results show that students' critical thinking abilities are in the low range, underscoring the need for innovative teaching strategies. One strategy to help students understand the material contextually, become more involved, and gradually build their critical thinking skills is to employ e-student worksheets based on the Problem-Based Learning (PBL) paradigm in conjunction with ethnoscience (Utami and Emiliannur., 2025). Based on the student learning style questionnaire, 51% of students have an auditory learning style. So that learning media are needed that can support their learning methods optimally. Therefore, E-student worksheet was developed as an interactive solution that not only provides text, but also audio and video features to improve critical thinking skills.

The teacher's assignments in the task analysis are either essay-style or multiple-choice questions, but they lack any indications of critical thinking. As a result, these questions do not challenge students to analyze, evaluate, or create new ideas. This limitation means that the tasks primarily measure basic understanding rather than higher-order thinking skills. Consequently, pupils' critical thinking abilities have not been able to be fully developed by these questions. Therefore, improvements in the design of learning tasks are necessary to better foster students' critical thinking skills.

According to the concept analysis and the teacher questionnaire, the physics content that students find most challenging to comprehend is motion kinematics. This demonstrates that most students struggle to grasp the idea of motion kinematics, particularly when it comes to applying and analyzing it. Their difficulties also indicate that traditional learning resources may not provide enough contextual support for understanding the concepts. Therefore, an improvement in instructional materials is necessary to address these learning gaps. E-student worksheets based on PBL integrated with ethnoscience are needed to help students understand the material more effectively and contextually.

Analysis of learning objectives is done by formulating the learning outcomes (CP) into a learning objective flow (TP). Then, the TP is further developed into a more detailed learning objective flow (ATP). From the ATP, indicators of achieving the IKTP learning objectives are derived. This structured process ensures that each learning objective is aligned with the expected competencies. It also helps teachers plan learning activities that are clear, measurable, and systematically connected to the curriculum.

Design Stage

The results from the definition step are used to guide the design process. The end result is an E-Student Worksheet that enhances students' physics critical thinking abilities by combining ethnoscience with problem-based learning. Its design needs to match the independent curriculum's CP. Liveworksheets is the platform utilized for implementation, and Canva is used for design in order to make the E-Student Worksheet more interactive. The E-Student Worksheet design is as follows.

The cover of the E-Student Worksheet includes general information such as the title, authors name, material, and relevant images. The cover layout and design should be visually appealing and informative to capture users attention, especially students. The choice of colors, fonts, and visual elements should align with the materials theme to create a professional yet engaging appearance.

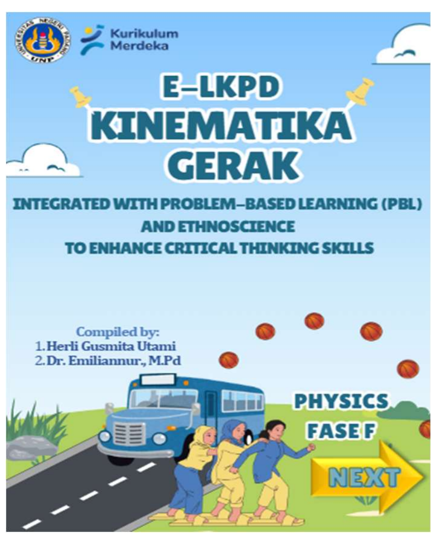
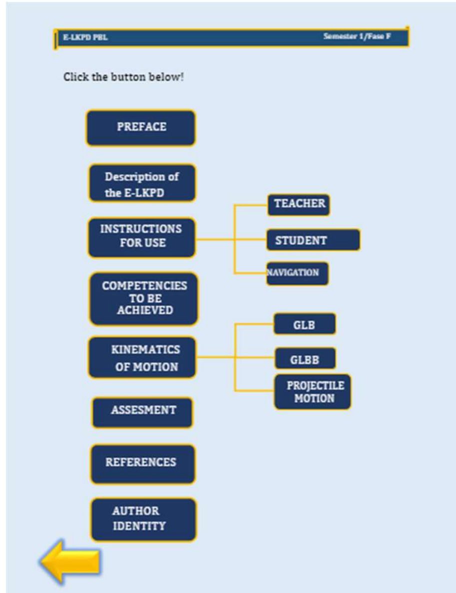


Figure 1. Cover

This table of contents covers several important parts of this E-student worksheet. Starting with the Foreword, Description of E-student worksheet, Instructions for Use, Competencies to be Achieved, E-student worksheet, Assessment, Bibliography, and Compiler Identity. With this structure, each item in the table of contents can be clicked and go directly to the relevant section in the E-student worksheet.



The purpose of the E-Student Worksheet is explained in the description. It also contains information on how to use the syntax and critical thinking indicators of Problem Based Learning (PBL). The description provides guidance for both teachers and students on how to implement the worksheet effectively. This ensures that the learning process aligns with the objectives of PBL and promotes critical thinking skills. The E-Student Worksheet description section is illustrated in Figure 3 to make it easier to understand.

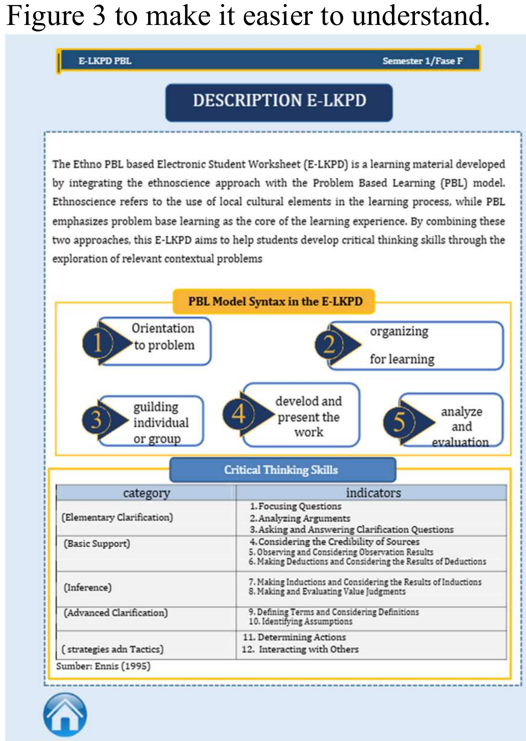


Figure 3. Description

Every activity in the E-Student Worksheet is structured according to the PBL syntax, which is systematically implemented at each stage of learning. Additionally, these activities align with Ennis's critical thinking indicators, enabling students to enhance their critical thinking skills effectively. This can be seen in Figure 4.

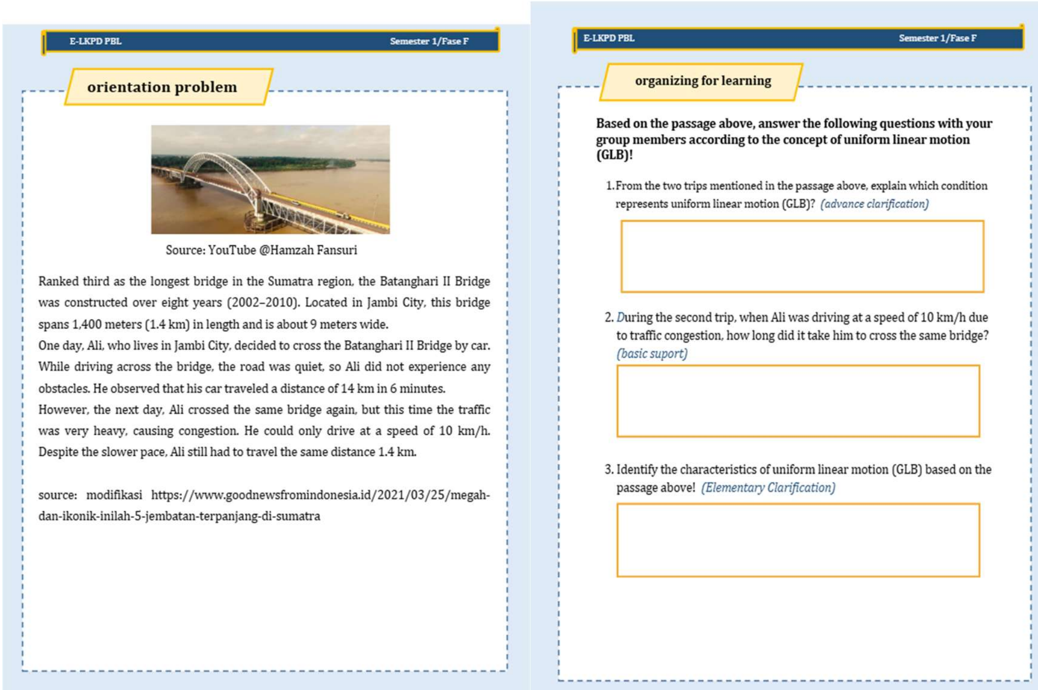


Figure 4. E-student worksheet

Development Stage

Validity data is obtained from the values given by the validator on the integrated PBL E-student worksheet validation instrument to improve students' critical thinking skills which are then analyzed. E-student worksheet is validated by 3 experts. The lowest score for each statement is 1 and the highest score is 5. The results can be seen in Figure 5.

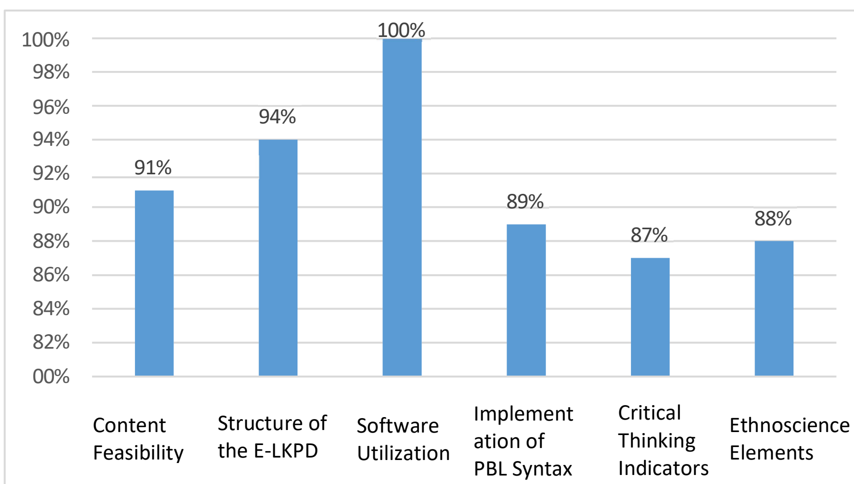


Figure 5. Plot of Average Values of All Components

Figure 5 shows that each component in the development of the learning materials received high average scores, indicating overall excellent quality. The software utilization component ranks the highest with a score of 100%, suggesting that this aspect is considered highly optimal in supporting the learning process. The structure of the electronic wroksheet and content feasibility also obtained high values, at 94% and 91% respectively, demonstrating that both the material and its presentation meet the expected standards. Meanwhile, the PBL syntax, ethnoscience, and critical thinking indicators received slightly lower scores is 89%, 88%, and

87%. yet still fall within the excellent category. These differences indicate that certain pedagogical aspects, particularly those related to learning processes and the development of critical thinking skills, could still be improved. Overall, the graph illustrates that the learning materials meet nearly all criteria at a very high level, with only minor room for improvement in the syntax and critical thinking indicator components.

Discussion

The definition step is the first research outcome. Initial-final analysis, student analysis, task analysis, concept analysis, and learning objective analysis are the five steps in the design process. This stage begins with distributing student needs questionnaires and conducting critical thinking ability tests on students. Based on the research conducted, several problems were found, namely: (1) there is no PBL-based E-student worksheet, (2) students' critical thinking ability is low, (3) Kinematic motion is one of the subjects that is difficult for students to understand. Integrated E-PBL student worksheets must be created based on the problems found. The PBL paradigm places a strong emphasis on problems and how students apply investigation, analysis, and reflection to find solutions (Mudrikah, 2021). In this context, students are faced with a problem that encourages them to think critically, work together in groups, and apply the knowledge and skills they have learned to find solutions. The Problem- Based Learning (PBL) approach is acknowledged for its capacity to assist students in developing their critical thinking abilities, in accordance with study by (Arifah et al., 2021).

The PBL model emphasizes problems, but if the problem is too difficult, students have difficulty analyzing and finding solutions. Therefore, variations in the PBL learning model can be supported by including local wisdom in the content of learning materials. In addition to supporting academic knowledge, through the PBL learning model with a local wisdom approach (ethnoscience) will support students' knowledge of the local wisdom of their region and/or place of residence (Nur et al., 2023). Thus, the E-student worksheet developed is integrated with PBL and ethnoscience to improve students' critical thinking skills in physics. According to Last Supper (2023), one of the efforts to stimulate critical thinking skills is to create innovations in teaching materials, namely E-student worksheet.

The next research finding is the design stage, which involves creating learning content and selecting E-Student Worksheet materials that enhance critical thinking skills. The components of the E-Student Worksheet follow the Ministry of National Education (2008) guidelines, including a cover, usage instructions, learning objectives, supporting information, task steps, and assessments. The cover is designed using Canva, while the content is developed in Canva and Microsoft Word before being converted into an electronic format using liveworksheets. According to Firtsanianta & Khofifah, 2022, a software called liveworksheets makes it easier to create e-worksheets and other educational resources. Conventional learning necessitates in-person classroom participation, whereas the E-Student Worksheet allows students to access materials at any time and from any location. This is one of the main differences between the two learning methods (Ricky Ardiansah & Zulfiani, 2023).

Findings from research during the development phase. The research findings at this point are the validation test results. Three experts who were UNP physics lecturers completed the validation sheet instrument, which yielded the validity test findings. PBL steps (Arends, 2012), ethnoscience, critical thinking ability indicators (Ennis, 1996), and the appropriateness of the content, the structure of the E-student worksheet, and the use of software were the validity components that were tested.

The design results of the E-Student Worksheet integrated with Problem-Based Learning and ethnoscience aim to enhance students' critical thinking skills in physics. The stages in PBL encourage students to develop independence and critical thinking in problem-solving (Munawaroh & Emiliannur, 2024). The critical thinking indicator evident in the student orientation to the problem phase is providing a simple explanation, where students identify key information from the given problem. In the organizing students to learn phase, practice questions are included that align with critical thinking indicators. During the investigation phase, the indicators of building basic skills and providing further explanations emerge. In the developing and presenting results phase, students apply the concluding indicator by summarizing findings, creating graphs from experiments, and presenting their results. This aligns with the findings of Amalia & Dewi (2024), which state that implementing the Problem-Based Learning (PBL) model can improve students' critical thinking skills.

The validation results of the E-Student Worksheet showed a score of 91.5, categorized as very valid. Based on the validation index by Riduwan & Sunarto (2012), the highest score was achieved in the software utilization component, while the lowest was in the critical thinking skills indicator component, which received 87% but still fell within the very valid category. During the E-Student Worksheet development stage, an evaluation was conducted. The validation process also included feedback and suggestions from the validator, which were then used to improve the developed E-Student Worksheet.

CONCLUSION

The findings of this research show that the Electronic Student Worksheet (E-LKPD) integrating Problem-Based Learning (PBL) and ethnoscience is highly valid, with a validity score of 91.5%. The high level of validity indicates that the developed product meets the criteria for quality learning materials. The assessment covers several aspects, including content feasibility, worksheet structure, software utilization, the implementation of PBL steps, and the inclusion of critical thinking indicators. In addition, the integration of ethnoscience elements ensures that the learning materials are contextual and culturally relevant. This combination helps students relate scientific concepts to real-life experiences, thereby enhancing engagement and understanding. The developed Electronic worksheet also encourages students to think critically, analyze problems, and propose solutions collaboratively. Therefore, the product is considered appropriate for classroom use and has strong potential to improve the quality of physics learning, particularly in motion kinematics.

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