

Analysis of Electronic Student Worksheets Matrix Requirements Using a PBL Flipbook Model to Stimulate Critical Thinking Skills

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Abstract

This research aims to evaluate the need for instructional media assistance during online learning in the topic of algebra. The research subjects involve 30 eleventh-grade students at Dirgantara Putra Bangsa Vocational High School. The method used is descriptive with a qualitative approach based on the Miles and Huberman model. The instruments in this research include a questionnaire containing an analysis of the needs provided to students and interviews with mathematics teachers at the school. The research findings include: (1) low critical thinking abilities of students; (2) the learning process is still conventional with lecture methods, limiting students' opportunities to express their ideas, interact, discuss, and participate during the learning process; (3) common errors in matrix materials; (4) the majority of students choose worksheets as the instructional material; (5) the majority of students have personal smartphones but only use them for communication. The conclusion of this research is the necessity of an e-Worksheet with a PBL-modeled matrix in the form of a flipbook to stimulate critical thinking skills.

Keywords: *E-Worksheet, Matrix, Problem Based Learning, Flipbook, Critical Thinking Skills*

INTRODUCTION

The 21st-century curriculum creates a paradigm shift in the teaching and learning process, with a focus on learners as the center (Tandon, 2020). Beyond a mere general approach, this curriculum demands detailed learning objectives, with a particular emphasis on enhancing critical thinking skills as integral to the entire education process (Gaspersz & Salamor, 2021). Johansson (2023) assert that critical thinking abilities, encompassing analysis, evaluation, synthesis, and the application of information to solve problems, form a crucial foundation for contextual and information-based decision-making. In the context of learning mathematics, critical thinking skills become a key element in formulating and solving solutions (Szabo et al., 2020). Therefore, the above exposition underscores the importance of learners in developing critical thinking skills.

The ability to think critically is not only relevant in the context of learning but also plays a crucial role in addressing everyday problems (Manurung et al., 2023). Alsaleh (2020) emphasizes that the implementation of intensive teaching methods, especially in mathematics lessons, can enhance the critical thinking abilities of learners. However, the level of critical thinking skills among learners is still considered low. The research findings of Maharani et al. (2023) indicate the low critical thinking abilities of Vocational High School students, especially in utilizing information related to circle equations. Similar conditions are also observed among high school students in topics such as sequences and series (Amoto, 2023). In conclusion, these constraints reflect that the critical thinking abilities of learners are still relatively low, highlighting the need for improvements in the use of instructional models to address these issues

In enhancing critical thinking skills, the teacher's instructional variations and the selection of appropriate teaching models, such as Problem Based Learning (PBL), support learners (Putri et al., 2020; Astuti & Sahono, 2022; Khishaaluhussaniyyati et al., 2023). PBL has proven effective in enriching critical thinking abilities with a foundation of knowledge, boosting learners' confidence, and promoting their independence (Gabuardi & Viviana, 2021; Smith et al., 2022; Tafakur et al., 2023). Other studies confirm the significant potential of PBL in improving learners' critical thinking skills (Noer & Gunowibowo, 2018; Pebriyani & Pahlevi, 2020; Pramestika et al., 2020).

Pramestika et al. (2020) found that PBL in mathematics education significantly enhances learners' understanding of mathematical problems. Mathematics holds great potential for advancing learners' abilities to think and argue in solving everyday problems (Moges, 2020). The success of mathematics education can be measured by learners' understanding and ability to solve mathematical problems (Palera et al., 2020). However, the reality indicates that learners often make mistakes when answering math problems, reflecting shortcomings in the learning process and understanding of specific mathematical concepts.

Mastering the concept of matrices is a crucial skill for eleventh-grade students, as emphasized by Kurniawan et al. (2021). Understanding matrices is not only relevant in an academic context but also applicable in daily life. This is particularly relevant for those undergoing vocational education at Dirgantara Putra Bangsa Vocational High School. Therefore, it is essential for students at this vocational high school to enhance their critical thinking skills related to the understanding of matrix material, and one way to achieve this is through the use of appropriate teaching materials.

One approach that can be adopted is the utilization of Student Worksheets as instructional materials. Student Worksheets is a sheet of paper containing a summary of lesson material and guidance for learners in carrying out tasks or learning projects (Utami et al., 2020). The implementation of Student Worksheets has the potential to develop problem-solving skills, formulate innovative ideas, and enhance the critical thinking abilities of learners (Ayunda et al., 2023). Research by Lestari et al. (2021) also confirms that Student Worksheets is effective in improving learners' mathematical critical thinking skills. Therefore, the use of student worksheets can be considered as an effective means to enhance the critical thinking abilities of learners.

To address the low utilization of smartphones by learners for educational purposes, steps need to be taken to enhance their usage. One approach that can be considered is the use of electronic Student Worksheets. The primary advantage of electronic Student Worksheets is its ability to improve learning effectiveness by providing easier access and overcoming limitations of space and time (Coman et al., 2020). In line with this, Nuci et al. (2021) highlight that electronic Student Worksheets can be an engaging tool, especially when learners' interest in learning is declining. Based on the previous explanations, the author concludes that there is a need for a mathematics learning media that effectively presents the material, ensuring that the learning process can be more efficient and assist learners in understanding the taught material. Therefore, the objective of this research is to analyze the needs of electronic Student Worksheets matrices with a PBL model, designed to stimulate the critical thinking abilities of learners.

METHODS

This research adopts a qualitative descriptive method. The descriptive approach is used to outline, explain, and detail an object, condition, or event according to its actual state (Rezaee et al., 2021). The focus of this research is to analyze the needs of electronic Student Worksheets matrices with a PBL model at the Vocational High School level to stimulate the critical thinking abilities of learners. The data collection methods applied in this research involve unstructured interviews, observations, and the distribution of instructional needs questionnaires. The research instruments include the use of questionnaires and interview guides.

Conducted at Dirgantara Putra Bangsa Vocational School, this research involved 30 eleventh-grade students who were selected through random sampling as research subjects. The data collection process was carried out by distributing questionnaires to the learners. Additionally, interviews were conducted with teachers to gather data and information regarding various characteristics of the learners,

types of media frequently used, challenging topics, as well as the expectations of teachers and learners related to instructional materials. The research utilized a questionnaire consisting of 6 questions, covering four aspects such as critical thinking skills, learning processes, common mistakes in mathematics topics, the use of instructional materials, and smartphone ownership and usage

The analysis method employed in this research follows the approach developed by Miles and Huberman. Sugiyono (2013) explained that the analysis process based on the Miles and Huberman model is conducted interactively and continuously until the data reaches saturation. This approach involves several data analysis techniques, including: (1) data reduction/collection, involving the simplification of data to provide a clear overview and facilitate the data collection process. Data reduction is carried out using modified observation sheets from previous research (Prasetio & Praramdana, 2020), and it includes interviews with mathematics teachers; (2) data presentation, which includes presenting the percentage of data in the form of matrices, graphs, charts, and others derived from observation and teacher interviews presented in note form; (3) verification/conclusion drawing, involving drawing descriptive conclusions based on the results of data analysis with reference to the literature review. Conclusions are drawn by describing the combination of observation sheet results and interview findings, while also referring to supporting theories.

RESULTS AND DISCUSSION

Based on the test results of the learners at Dirgantara Putra Bangsa Vocational High School, the lack of critical thinking skills among the learners is revealed through the percentage of achievement indicators in the Critical Thinking Test results, as depicted in Figure 1.

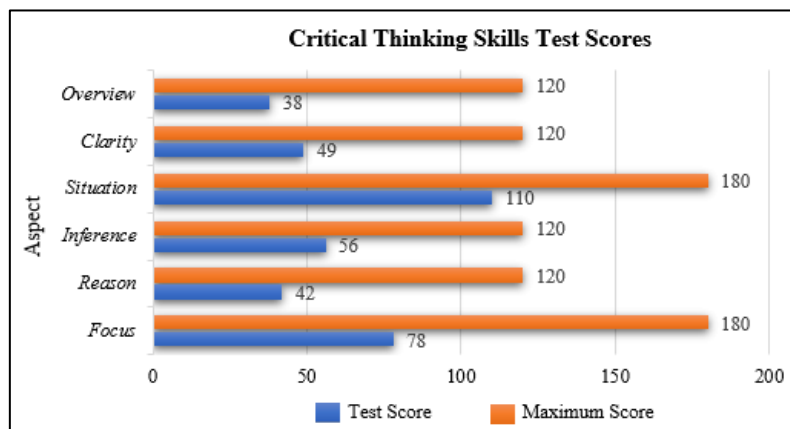


Figure 1 Attainment of Learners' Critical Thinking Indicators

Based on Figure 1, it can be observed that learners scored 78 on the focus indicator, indicating a good understanding of the given problems. On the reason indicator, learners achieved a score of 42, demonstrating their ability to record information using appropriate mathematical formulas. The inference indicator showed a score of 120, indicating learners' ability to draw preliminary conclusions. On the situation indicator, learners obtained a score of 110, showing their ability to use all information to answer questions. On the clarity indicator, learners scored 49 in providing further explanations about the conclusions made. Meanwhile, on the overview indicator, learners scored 38 in drawing conclusions from the entire activity. Thus, the average test score on each indicator obtained by learners is 62.16, indicating that improvement is still needed. This aligns with the findings from interviews conducted with one of the mathematics teachers, as outlined below."

- P : What are the difficulties faced by students during classroom learning?
GM : Students still face difficulties in solving some contextual problems, relying solely on memorizing formulas, lacking precision, not yet capable of deep thinking, and experiencing challenges when given exercises involving contextual problems. At times, they also struggle

to draw conclusions from the material, use information from the problems to solve issues, articulate learning objectives, and evaluate the correctness of the activities they have undertaken.

The survey results at Dirgantara Putra Bangsa Vocational High School aimed to gather students' responses to the teaching of matrices in the classroom. The selection of questions in the questionnaire was based on interviews with teachers involved in the previous learning process with the students. The findings from the survey can be seen in Figure 2.

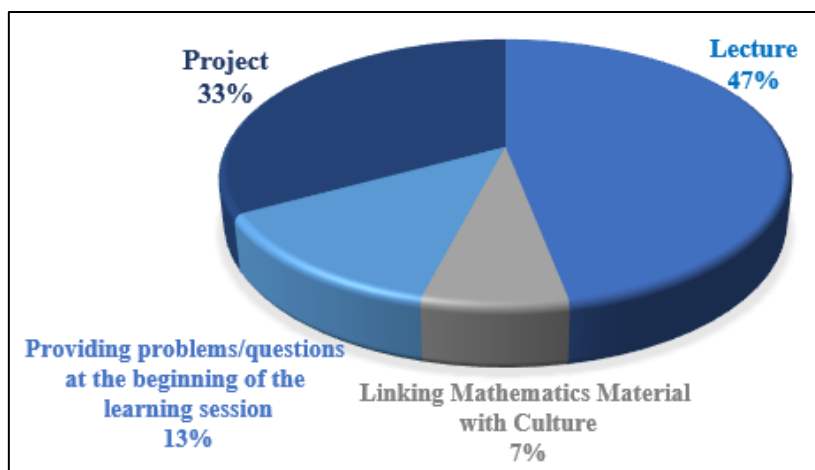


Figure 2 Results of Learners' Responses Regarding the Learning Process

In Figure 2, it is shown that 47% of teachers still use lecture-based teaching methods, limiting students' opportunities to communicate their ideas, interact, discuss, and participate during learning. This finding aligns with the interactions observed during an interview with a mathematics teacher, as follows.

- P : How does the teacher deliver instructional material during class?
GM : The delivery of instructional material in regular teaching is typically done directly or conventionally because the majority of students still face several obstacles, particularly related to a lack of engagement.

The use of Problem Based Learning in mathematics education can significantly enhance students' understanding of mathematical problems and their skills in finding solutions (Juandi & Tamur, 2021). Mathematics has the potential to improve critical thinking, argumentation, and problem-solving skills in everyday situations, including aspects of dimension determination, characteristics, structure, patterns, correlations, as well as rational and logical thinking (Çelik & Özdemir, 2020). Therefore, Baiduri et al. (2020) state that the success of mathematics education can be measured through the level of understanding and students' ability to solve mathematical problems. However, students often make mistakes when answering math problems, indicating imperfections in the learning process and understanding of certain mathematical concepts (Loibl & Leuders, 2019).

Based on Figure 3, it can be observed that at Dirgantara Putra Bangsa Vocational High School, there are several common mistakes frequently made by students when solving mathematics problems in eleventh-grade. Through the figure, it is evident that the level of errors made by students in handling mathematical problems in the Matrices topic reaches its peak at 47%, as compared to other topics such as System of Linear Equations and Inequalities 40%, Absolute Value 13%, and Composition of Functions 3%. This aligns with the interview findings conducted with one of the mathematics teachers, as follows.

- P : Which topics are considered difficult to identify the problems for?
GM : The majority of students are unable to identify questions in the matrix material, making it difficult for them to solve these problems

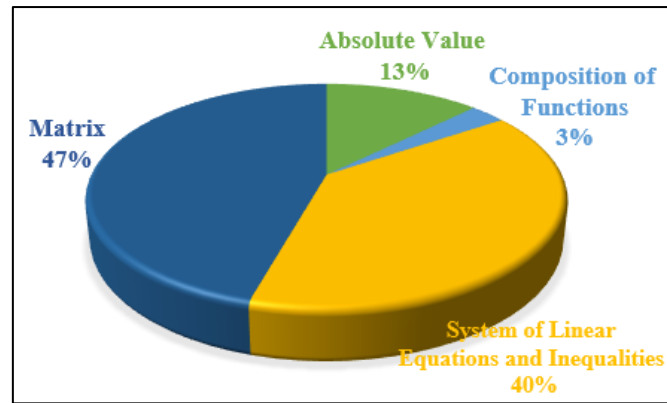


Figure 3 Results of Responses to Common Mistakes Made by Students in eleventh-grade Mathematics

The research conducted by Khairan and Kartini (2021) indicates that students often make various types of errors in solving mathematical problems, including errors in facts, concepts, principles, and operations related to matrices. The study emphasizes that mastering matrices is a key skill that needs to be acquired by eleventh-grade students (Kurniawan et al., 2021; Marufi et al., 2022). The importance of understanding the concept of matrices is also relevant to its application in everyday life, especially for those undergoing vocational education, as is the case at Dirgantara Putra Bangsa Vocational High School. Based on the distribution of questionnaires to student respondents regarding the learning process in the classroom, the results are obtained as shown in Figure 4.

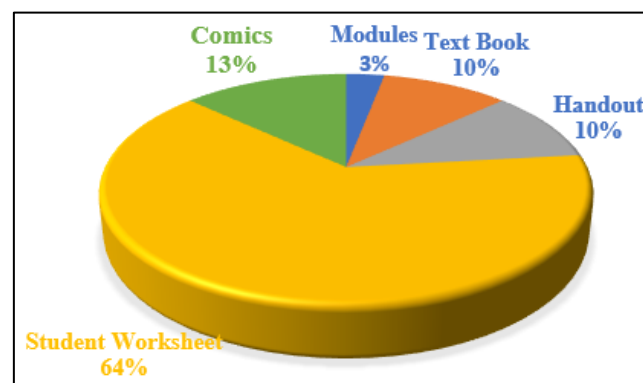


Figure 4 Results of Students' Responses to the Use of Teaching Materials

In Figure 4, it is shown that teaching materials preferred by students in group settings are predominantly Student Worksheets at 64%, Comics at 13%, Modules at 3%, while Textbooks and Handouts each at 10%. This aligns with the researcher's observation of the teaching materials currently used by mathematics teachers, who rely on printed books published by the Ministry of Education and Culture. Meanwhile, the adopted Student Worksheets come from “Viva Pakarindo” titled 'Practical Learning Mathematics'. These worksheets include brief material summaries, practice problems, daily assessments, and mid-semester assessment exercises. However, the researcher did not find any specific teaching models explained in these worksheets.

Based on the distribution of questionnaires to student respondents regarding smartphone ownership, the results are obtained as shown in Figure 5. Figure 5 provides information that 67% of the smartphones are personally owned by the students, while 33% belong to their parents. The usage of smartphones by students also indicates high intensity, with 44% utilizing them for communication, 33% for learning activities, 13% for playing games, and 10% for watching video content. These statements can be observed in Figure 6.

With the low percentage of students using smartphones for learning purposes, there is a need for development efforts to leverage smartphones for educational activities. One strategy that can be implemented is the use of electronic Student Worksheets. The advantages of electronic Student Worksheets include its ability to enhance learning effectiveness by facilitating access and overcoming

space and time constraints (Al-Malah et al., 2020). In line with this, Prabandari et al. (2022) emphasize that electronic Student Worksheets plays a crucial role as an engaging tool, especially when learners' interest is declining.

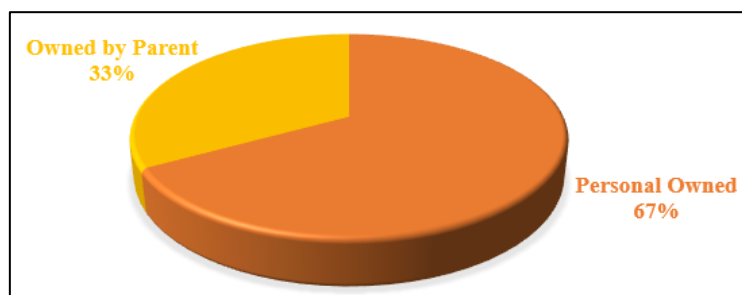


Figure 5 Results of Students' Responses Regarding Smartphone Ownership

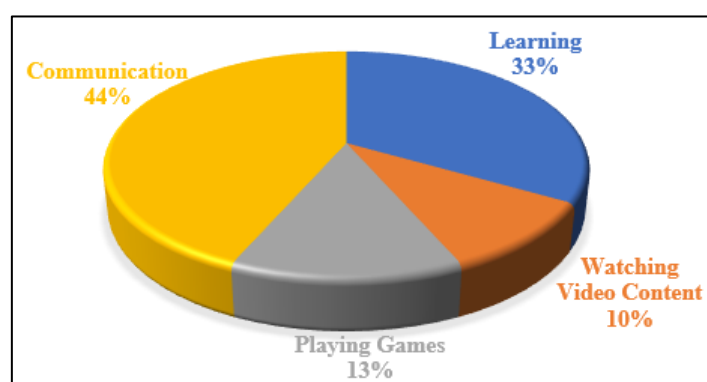


Figure 6 Results of Students' Responses to Using Smartphones

According to Roemintoyo and Budiarto (2021), teachers not only need to have mastery of the subject matter but it is also important for them to understand and master the methods of delivering mathematical content using various applications, one of which is flipbooks. A flipbook is a classic animation form made up of a series of sheets arranged like a thick book, where each page depicts a process, so when these pages are flipped, it creates the illusion of movement or animation (Lamotte, 2022). The use of flipbook media can enhance critical thinking and also influence the academic achievement or learning outcomes of students (Sudiarti et al., 2023). Based on the information above, an electronic Student Worksheets matrix in the form of a flipbook modeled on PBL to stimulate critical thinking skills is needed.

CONCLUSION

Based on the results and discussions above, the following conclusions can be drawn: (1) low critical thinking skills among students; (2) the learning process is still conventional with lecture methods, limiting students' opportunities to express their ideas, interact, discuss, and participate during the learning process; (3) frequent errors in the matrices material; (4) the majority of students choose Student Worksheets as their preferred teaching material; (5) the majority of students have personal smartphones and only use them for communication. Based on the results and analysis of the research, it can be concluded that eleventh-grade students at Dirgantara Putra Bangsa Vocational High School need an electronic Student Worksheets matrix modeled on PBL in the form of a flipbook to stimulate critical thinking skills.

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DATA AVAILABILITY STATEMENT

Data will be made available on request.

CONFLICT OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.

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