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Development of *Papan Nilai Tempat* Learning Media to Improve Students' Critical Thinking Skills

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ABSTRACT

This study aims to develop the PANIPAT *(Papan Nilai Tempat)* learning media to improve students' critical thinking skills that is valid, practical, and effective. This study is based on the importance of students' critical thinking skills, as with critical thinking skills, students can think rationally and make the best choices for themselves.This study used the Research and Development (R&D) method with the ADDIE development model. The instruments used included expert validation sheets, questionnaires, and critical thinking skills test sheets. The results of this study showed that the PANIPAT media was considered highly feasible for use, with an average validation score of 87.15%, categorized as feasible. The average score from teacher and student questionnaires was 96.4%, which is classified as very practical. In addition, the N-Gain result was 66%, which is classified as effective. The conclusion of this study indicates that the PANIPAT media is capable of making a significant contribution to improving students' critical thinking skills, particularly in mathematics learning.

Keywords: development, instructional media, critical thinking

INTRODUCTION

Critical thinking is a skill that focuses on how to make decisions that must be trusted, put into action, and held accountable for[1]. Critical thinking is a higher-order thinking ability that consists of problem analysis, identifying problems, problem-solving, drawing conclusions, and evaluation[2]. In general, critical thinking is thinking clearly, thoroughly, knowledgeably, and fairly when believing in or doing something[3]. Critical thinking is a process carried out to find meaning by using processes when facing problems that must be solved, and making decisions[4]. Critical thinking skills are the way we think about a subject, content, or problem,whichshows the quality of thinking and the ability to draw conclusions based on the problem[5].Critical thinking in mathematics is the ability and disposition to involve prior knowledge, mathematical reasoning, and the use of cognitive strategies in generalizing, proving, or evaluating unfamiliar mathematical situations in a reflective manner[6].

Based on several opinions above, it can be concluded that critical thinking is an individual's ability to make accurate and accountable decisions by analyzing, reviewing, and evaluating problems thoroughly. This ability involves problem identification, problem solving, and drawing accurate conclusions to ensure that the decisions made are the best ones.

Critical thinking skills are highly necessary for every individual. Zanthy resolves various problems that exist in life. Through critical thinking, a person can organize, modify, and adjust their way of thinking to make accurate decisions[7]. A person who thinks critically is usually more skilled in reasoning and tends to trust and act according to their reasoning. This skill is highly required in preparing every individual and student to be well-prepared for global challenges[8].

Critical thinking skills are also very important for students because, with these critical thinking skills, students can behave rationally and make the best choices for themselves. Students who possess these critical thinking abilities will also consistently question themselves in every situation they face to determine what is best for them. In addition, critical thinking skills will also be embedded in their character and personality, as well as implemented in all aspects of their lives[9]. Critical thinking is important for students to analyze and map out answers or solutions to every problem they will face in the future[10]. Critical thinking skills also need to be introduced to students; thus, they can investigate and express problems that happen in daily life[11]. These critical thinking abilities can also become one of the indicators of students' success in solving mathematical problems[12].

The role of mathematics in elementary school age is to prepare students to become individuals who are

able to face changes in life circumstances through mathematical ways of thinking[13]. The goal of learning mathematics is for students to be able to understand mathematical concepts, solve problems, and connect mathematical ideas in accordance with the curriculum[14]. Critical thinking skills and mathematical problem-solving abilities in students are very important to be improved[15]. According to Sulistiani and Masrukan, critical thinking is necessary in mathematics learning because critical thinking in mathematics learning can minimize errors in solving problems, and in the final result, accurate solutions and conclusions will be obtained[16]. However, in reality, research shows that the critical thinking ability of students at the elementary school age is still relatively low. According to Fitriya et al., the ability of Indonesian students in solving problems related to critical thinking activities shows a very low level of competence[17]. The lack of students' critical thinking skills is affected by several factors, including the tendency of students to focus more on understanding material and formulas rather than understanding concepts[18].

One of the common difficulties faced by students in arithmetic is when learning place value material. In that study, some children had not yet understood place value, such as units, tens, thousands, and so on. Students' lack of understanding of place value material will further complicate their learning when they are faced with non-base ten numbers[19]. In addition, according to the research findings of Tubal, verbally students are generally able to fluently mention one-digit and two-digit numbers, but experience difficulties when mentioning numbers with more than three digits[20].

At the concrete operational stage, between the ages of 7 and 12, children are sufficiently mature to use logical thinking and arithmetic operations. However, without physical objects directly in front of them, children at this concrete operational stage still experience difficulties in carrying out tasks that require logical or critical thinking[21]. In creating quality learning, a teacher often experiences difficulties in delivering and explaining learning material, especially in mathematics lessons[22]. Based on this, learning in elementary school requires innovation in the form of learning media. To improve students' critical thinking skills, it is necessary to have media that can guide students in the learning process[23]. The media used to enhance students' critical thinking skills in the place value material in this study is the Place Value Board media.

A previous study conducted by Puspasari[24], found that the use of number board media could improve learning. The research results showed that the use of number board material could enhance the learning objectives of place value for second-grade students. The average learning outcome increased from 72.22 with a mastery level of 62.9% in the first cycle to 92.59 with a mastery level of 100% in the second cycle, which indicates this result.

Subsequently, a study conducted by Hana[25], showed that the average student learning outcome in Cycle I was 74, with a classical mastery of 57%. The observation result in Stage I was 76%. The results in Cycle II showed an average learning outcome of 85 with a classical mastery of 86%, and the observation result in Stage II was 83%. Therefore, the research results indicated that the use of place value board media for units and tens affected improving mathematics learning outcomes in the place value material of units and tens for Grade I students at SD Djama'atul Ichwan Surakarta.

Another study that discussed the place value board media was conducted by Puspitasari[26], showed that the use of the place value board significantly improved students' understanding of the concept of place value and their ability to read and write large numbers. This media also provided additional benefits, including increased interest and student engagement in mathematics learning.

Based on previous studies, the researcher is interested in conducting further research on the development of Place Value Board media to improve the critical thinking skills of second-grade students in MI/Elementary School. This Place Value Board media can present information visually and facilitate the understanding of the relationships between digits in a number. Therefore, this study aims to explore the effectiveness of and develop the place value board media in helping students understand and apply the concept of place value in mathematics learning.

This place value board media is a student-oriented medium made of plywood and board, which is then colored in four sections according to place value (thousands, hundreds, tens, units) and equipped with number boards that can be shifted depending on their place value. This media can foster children's learning interest, making classroom learning more enjoyable[27]. The place value board media developed in this study is very useful in mathematics learning, especially to help students understand the concept of place value more concretely and visually. With each place value represented by a different color, students can easily distinguish the positions of units, tens, hundreds, and so on.

Based on the description of facts and the background above, this study aims to develop a product in the form of Place Value Board media that is valid, practical, and effective to improve students' critical thinking skills.

RESEARCH METHOD

This study was a development research (Research and Development). Sugiyono states that this method is a research method used to produce a product as well as to test the effectiveness of the product[28]. Research and Development (R&D) is a term used to describe activities carried out to create new and improved products and processes[29].

This study used the ADDIE development model to produce a product aimed at training critical thinking skills. The ADDIE model consists of five stages: analysis, design, development, implementation, and evaluation. Similar to the development model of database systems,

the core activities in each development stage are alike. Therefore, this model can be used for various types of product development, such as models, learning strategies, teaching methods, media, and instructional materials[30].

At the product trial stage, this study used a one-group pretest-posttest design, which is one type of design within the pre-experimental approach. This design was conducted by giving a pretest to students before the use of learning media, followed by a treatment in the form of learning using the PANIPAT media, and finally administering a posttest after the treatment. The objective of this design is to observe any improvement in students' critical thinking skills after using the developed media. This study involved only one group without a control group, so the comparison of student learning outcomes was based on the difference between pretest and posttest scores.

At this stage, the researcher also planned the form of the product to be developed. In the design stage, the researcher began designing the media, identifying the materials and resources that had been collected, and developing the research instrument. Then, the development stage. Activities in this stage included producing the media according to the planned design, which was then validated by experts to ensure that the media was feasible for use in learning.. After that, in the implementation stage, the researcher conducted a media trial in the classroom to ensure that the media functioned according to the planned design. The final stage is the evaluation stage; this stage was carried out to assess the success level of the developed media. This was also done to revise the activities that had been conducted.

The data collection techniques in this study were questionnaires and tests, which were used as the primary methods for collecting research data. In this study, the data obtained were analyzed both qualitatively and quantitatively. Qualitative data were used to describe the product development process and were obtained through feedback and suggestions from validators. Meanwhile, quantitative data were used to assess the quality of the product and were obtained through validation questionnaires, student and teacher response questionnaires, as well as pretest and posttest assessments.

This study used the Likert Scale to assess the feasibility and appropriateness of the developed media. According to Asrul, Hasan, and Muhktar, the Likert Scale is a questionnaire statement consisting of two types of statements, namely positive statements and negative statements. This form of table is presented in the following table[31]:

Table 1. Guidelines for Instrument Response Criteria

Score	Criteria
5	Strongly Agree
4	Agree
3	Neutral
2	Disagree
1	Strongly Disagree

1. Feasibility Data Analysis

To examine and calculate the feasibility results of the developed media according to material and media experts, the Fariyanti formula can be used as follows[32]:

$$P = \frac{\Sigma x}{\Sigma xi} x\ 100\%$$

Based on the results of the questionnaire data calculation from material and media experts, the percentage score obtained is interpreted using the following reference scale:

Table 2. Feasibility Criteria

Criteria	Score Range
Feasible	75 ≤ × < 100
Moderately Feasible	56 ≤ × < 75
Less Feasible	40 ≤ × < 55
Not Feasible	0 ≤ × < 39

2. Practicality Data Analysis

The next data analysis is the analysis of teacher and student questionnaire data, which is used to determine the practicality of the media. To assess this, the researcher used the following formula[34]:

$$P = \frac{Total\ overall\ score}{Maximum\ score \times number\ of\ students}\ x\ 100\%$$

The average score result is then interpreted using the following scale:

Table 5. Practicality Criteria

Percentage (%)	Criteria
81–100	Very Practical
61–80	Practical
41–60	Moderately Practical
21–40	Less Practical
0-20	Not Practical

3. Effectiveness Data Analysis

The effectiveness analysis was obtained from the results of the students' pretest and posttest. To determine the effectiveness of the media, the N-Gain (g) formula can be used as follows[33]:

$$N - Gain = \frac{Posttest\ Score\ -\ Pretest\ Score}{Ideal\ Score\ -\ Pretest\ Score}$$

The average N-Gain score is then classified according to the following table:

Table 4. Effectiveness Criteria

Percentage	Classification
N-Gain > 0.7	High
0.3 ≤ N-Gain ≤ 0.7	Medium
N-Gain < 0.3	Low

RESULTS AND DISCUSSION

1. Analysis Stage

The analysis stage was the first step taken by the researcher in designing the learning media in the form of a place value board. This media was developed to improve students' critical thinking skills. Through the analysis process, the researcher was able to formulate the objectives of the media to be developed, determine the method of delivery, and prepare a plan based on the information collected, such as the condition of students during the teaching and learning process in the classroom, as well as the curriculum used. This information was obtained from direct observations conducted by the researcher in Grade II of SD No.091566, Bah Jambi, Simalungun Regency.

In addition, the researcher also conducted informal interviews with the classroom teacher to obtain additional information regarding the learning approaches that had been used, the limitations of the available learning media, and the predominant learning styles of the students in that class. Based on this information, it was found that the learning process was still predominantly one-way and lacked the use of interactive concrete media.

Subsequent, the researcher developed an instrument to assess students' critical thinking skills in the form of a scoring rubric, which was constructed based on the indicators of critical thinking skills, namely: (a) Elementary Clarification, (b) Basic Support, (c) Inference, (d) Advanced Clarification, and (e) Strategy and Tactic.

2. Design Stage

In the design stage, the researcher began designing the initial concept of the place value board media to be developed. The media design was adjusted to the characteristics of second-grade elementary school students, who require concrete, visually engaging, and easy-to-understand learning media. In this stage, the researcher also designed the content structure, determined the form and components of the media, and selected appropriate colors, sizes, and materials to support student engagement in learning and encourage them to think critically.

The researcher determined the main components of the media, such as the columns for units, tens, hundreds, and thousands, as well as spaces for placing the corresponding numbers. The selection of font, color, and font size was also considered to enhance readability and visual appeal. The media were designed using materials that are safe, durable, and easy to use in the classroom environment. This design stage served as a critical foundation to ensure that the developed media is not only visually appealing but also functional and aligned with students' needs in understanding mathematical content, particularly the concept of place value.

3. Development Stage

In the development stage, the researcher began to realize the design of the place value board media based on the plans that had been prepared in the previous stage. After the product was completed, the researcher conducted validations by a subject matter expert and a media expert. This evaluation aimed to assess content feasibility, visual appearance, ease of use, and the alignment of the media with learning objectives. Based on the suggestions and input from the experts, the researcher made revisions to the media, both in terms of design and content, to improve its quality and effectiveness. The assessment results obtained from expert validators can be seen in Table 5 below.

Table 6. Validation Test Results

Type of Validator	Validation Score (%)	Criteria
Media Expert	88.6	Feasible
Material Expert	85.7	Feasible
Average	87.15	Feasible

Based on the validation test results presented in Table 5, it was found that the developed learning media received a feasibility score of 88.6% from the media expert and 85.7% from the material expert, with an average score of 87.15%. All of these scores fall into the "Feasible" category, which means that the media meets the requirements for use in learning activities. These findings indicate that the media have met quality standards in terms of visual appearance, navigation, consistency, and content alignment with the curriculum.

One of the factors that contributed to the high score from the media expert was the attractive media design, the use of contrasting yet harmonious

colors, and the arrangement of menus that were easy to use. From the material aspect, the high validation score indicated that the content in the media was aligned with the basic competencies and was presented systematically and communicatively. This is in line with the study conducted byPrastowo [35]who emphasized that media designed with attention to instructional design principles and content integration tends to receive high feasibility scores from experts.

The strength of this study lies in the involvement of two validators with different areas of expertise, which provided a comprehensive assessment from both design and content perspectives. In addition, the validation instruments used had undergone a trial process, resulting in more reliable data. However, this study has limitations in terms of the number of validators and the scope of media testing, which was still limited to a specific environment.

Compared to previous studies, for example, Amalia & Setiawan[36], who developed interactive learning media for elementary school and obtained an average validation score of 84.3%, the media in this study achieved a higher score. This indicates that the media development approach used in this study was more optimal, both in terms of design and content. This finding is also supported by the study of Yunita et al. (2020), which stated that interactive learning media that meet graphic design and pedagogical criteria can enhance students' interest and engagement in the learning process.

These results imply that the media developed is not only feasible in terms of technical and substantive aspects but also has the potential to be used as an instructional innovation in elementary schools. This media can support teachers in delivering material more engagingly and interactively, as well as enhance learning effectiveness. The contribution of this study also lies in providing a media model that can be replicated or further developed for different subjects and educational levels.

4. Implementation Stage

The implementation stage was carried out to test the practicality and effectiveness of the place value board media in Grade II elementary school learning. During the implementation process, the researcher observed how the media was used by students and collected data through student response questionnaires.

The practicality score of the place value board media, based on students' response assessments, showed an average score of 96.2%, which is classified as "very practical." Furthermore, the results of the teacher response questionnaire showed an average score of 96.6%, also classified as "very practical.".

This indicates that the place value board media is easy to use by students, engaging, and able to assist them in understanding the place value material effectively. In addition, this place value board media facilitates teachers in explaining the concept of place value in a concrete and visual manner, making the material easier for students to understand. To measure the effectiveness of the media, the researcher examined the pretest and posttest scores. Based on the results of data analysis, the pretest and posttest scores can be seen in Table 6 below:

Table 7. Pretest and Posttest Results

Subject	**Average Score Obtained (%)**	
	Pretest	***Posttest***
Students	71.6	91.4
Average N-Gain: 0.66	0.66	
Percentage: 66%	66%	

Table 6 shows an improvement in students' learning outcomes after using the developed learning media. The average pretest score obtained by 19 second-grade students was 71.6%, while the posttest score increased to 91.4%. Based on the calculation, the average N-Gain score was 0.66 or 66%, which is classified as medium according to Hake's classification (1998). This improvement indicates that the learning media used were reasonably effective in helping students enhance their critical thinking skills.The increase in scores could be attributed to several factors. First, the learning media that had been developed were designed to be attractive and easy to use, thereby encouraging students to be more active in the learning process. Second, the content presented was aligned with the basic competencies and had been systematically organized, making it easier for students to understand the concepts being studied. Third, the learning model that was implemented was interactive and student-centered, which enabled students to think independently and critically.

Compared to previous studies, these findings are consistent with the results of research by Amalia and Setiawan[36], who developed Android-based interactive learning media and obtained an N-Gain score of 0.64, also classified as medium. In addition, Yunita et al.[37]also showed that the use of interactive media based on Lectora Inspire significantly improved students' learning effectiveness. Thus, the results of this study support previous findings that well-designed learning media can enhance student learning outcomes, particularly in the aspect of critical thinking.

The strength of this study lies in the use of a quantitative method with a one-group pretest-posttest design, which allows for direct analysis of the improvement in learning outcomes. However, its limitation is the absence of a control group and

the limited sample size, so the generalization of the results of this study still needs to be further tested in a broader context.

These findings imply that the developed learning media have been proven to significantly improve students' critical thinking skills. Therefore, this media can become an effective alternative for learning and make a meaningful contribution to the development of innovative teaching materials at the elementary education level.

5. Evaluation Stage

The final stage of this study is the evaluation stage. This evaluation stage aims to assess the overall quality of the media after going through the processes of validation, implementation, and trial. Based on the validation results from the material expert and the media expert, there were several aspects that needed to be revised by the researcher. After making the revisions, the media was stated to be generally following feasibility standards and feasible for use.

In addition, during the implementation process, no comments or suggestions were found from students regarding the use of the media. Students' responses were more tending to be positive, and they were able to use the media effectively without experiencing difficulties. This indicates that the place value board media has fulfilled the aspects of ease of use, attractiveness, and relevance to the material being studied.

This study produced a product in the form of a place value board media. The place value board media is a concrete medium that helps students understand mathematics, particularly in the topic of place value[38]. The place value board media was developed as an alternative solution to help students grasp the concept of place value more easily while also stimulating their critical thinking skills. In its implementation, this media not only offers concrete visualization but also encourages students to think actively, observe, and draw conclusions. This is in line with the study conducted by Viranny and Wardhono, which explained that the place value board media can improve students' critical thinking skills and help them understand the material[39].

Students' critical thinking skills were measured based on the five critical thinking indicators proposed by Ennis. These five indicators are: providing elementary clarification, building basic support, making inferences, providing advanced clarification, and formulating strategies and tactics. According to the study conducted by Padmakrisya and Meiliasari, critical thinking skills are essential abilities that students must possess in 21st-century learning. These skills enable students to understand concepts deeply, evaluate information critically, and make appropriate decisions[40].

The PANIPAT (*Papan Nilai Tempat*) media has several advantages that support the development of students' critical thinking skills, particularly among second-grade elementary or MI students. The first advantage is that this media presents attractive and contrasting colors, which can capture students' attention while also making it easier for them to clearly distinguish place values (units, tens, hundreds, thousands). This helps students fulfill the first critical thinking indicator, namely elementary clarification, as they can easily observe and explain the position and value of numbers based on the distinct colors and concrete forms. As stated by Alfiana et al., the use of concrete media with attractive colors, such as thePANIPAT, is effective in helping students clearly and logically explain the concept of place value[41]. The second advantage is that it presents the concept of place value concretely and visually. In the indicator of building basic support, students are trained to observe, recognize, and identify patterns of numerical changes and relate them to positional values. This activity trains critical thinking skills such as observation, data identification, and understanding the relationships between pieces of information. The use of visual media is highly beneficial for students in strengthening basic skills in mathematics learning[42]. The third advantage is that the media can be directly moved by students from one column to another using the sliding board. This can help students make inferences about the place value system. It reflects both inductive and deductive thinking processes. The study conducted by Jannah et al. supports the notion that concrete media in mathematics learning enables students to develop inference skills through direct experience[43]. The fourth advantage is that it can promote conceptual understanding. This supports students in providing advanced clarification, where they not only know the result but can also explain why mathematical rules work. According to research by Munthe et al., manipulative media encourage students to explore the reasoning behind mathematical operations rather than simply memorizing numbers. The fifth advantage is that the PANIPAT media is designed with systematic steps for arranging numbers[44]. Students not only arrange numbers randomly, but they also begin to consider the logical sequence of each number. This can enhance students' skills in organizing strategies and tactics in planning solutions and evaluating results. Research by Widiastini shows that students who use interactive board media are more capable of designing and applying problem-solving strategies[45].

The research results showed that the use of PANIPAT media had a positive impact on improving critical thinking skills in second-grade students when learning the concept of place value. This was evident from the comparison of students' pretest and posttest results, which showed a significant improvement. Before the use of the media, many students experienced difficulties in understanding the abstract concept of place value. They were more likely to memorize without truly understanding the position of numbers and the value of each digit.

After the use of PANIPATmedia, students showed a change in their way of thinking. They were not only able to state the place value, but also able to explain the reasoning behind their answers, such as why a certain number belongs in the tens or hundreds place. This indicates that the learning process, which was previously passive, has become more active and meaningful.

This change can be logically understood. The PANIPAT media was designed with a concrete, visual, and manipulable approach, which aligns with the way children at the elementary school level think. The variation in colors and shapes on the board helps students distinguish the positions of numbers, while the activities of arranging and moving board components engage them physically and mentally in the learning process. This engagement is the key to the development of critical thinking skills. Students do not merely receive information but also analyze, compare, and draw conclusions through direct experience.

The strength of this study lies in the innovation of a simple yet effective interactive learning media, developed based on the actual needs of elementary school students. In addition, the media developed in this study is easy to produce and made from readily available materials. This makes the PANIPAT media highly potential for widespread application by teachers, especially in schools with limited resources. However, this study also has its limitations. It was conducted on a small scale (19 students), without a control group, and within a limited time frame. Therefore, further research is needed on a larger scale, over a longer period of time, and involving a control group so that the results are empirically stronger and can be compared across different conditions.

Overall, the results of this study indicate that the PANIPAT media is able to make a significant contribution to improving the critical thinking skills of second-grade elementary/Islamic elementary students. These findings are consistent with the view of Multahada et al., who stated that the use of place value board media in mathematics learning can gradually improve students' understanding through a contextual and concrete approach. This media not only helps students understand the concept of place value more easily but also encourages them to think actively and logically[46]. This study implies that teachers can use the PANIPAT media as an alternative instructional tool in teaching mathematics, particularly on the topic of place value. This tool not only enhances conceptual understanding but also helps to cultivate critical thinking habits from an early stage. In addition, the findings of this study contribute to the development of context-based learning media that are simple, affordable, and easily applicable in real classroom settings.

CONCLUSION

Based on the results of the research and trials that have been conducted, it can be concluded that the development of the PANIPAT media successfully went through all stages of the ADDIE model systematically, starting from needs analysis to effectiveness evaluation. This media was found to be effective in improving students' critical thinking skills. This was demonstrated by the improvement in students' learning outcomes from pretest to posttest, as well as the positive responses from both students and teachers regarding the use of the media. This media was found to be highly valid, with an average score of 88.6% from the media expert and 85.7% from the material expert, both of which fall into the feasible category for use in learning. Thus, the PANIPAT media is not only useful as a visual aid but also serves as a means of developing critical thinking skills at the elementary school level.

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