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Development of problem mind mapping-based learning model (PMM-BL) integration patterns to improve critical thinking skills in primary school students

Lita Ariyanti[1*], Fattah Hanurawan[2], M. Ramli[3]
[1,2,3]University of Malang, Indonesia; lita.ariyanti.2121039@students.um.ac.id (L.A.).

Abstract: PISA 2022 data shows that Indonesia's ranking has risen 5-6 positions compared to PISA 2018. However, even though there was an increase in ranking in PISA 2022, Indonesia recorded a decrease in scores in each ability assessment subject. Therefore, Indonesia actually still has the opportunity to develop a model (PMM-BL) integration patterns to improve critical thinking skills because it has the capacity and potential that have not yet been developed. The purpose of this research is to produce a PMM-BL model book product and its operational form to improve critical thinking skills and test differences in students' critical thinking skills before and after implementing the PMM-BL. The research subjects during the limited trial of the PMM-BL model were fifth-grade students at SDN Bandulan 2, Malang City, Indonesia. The research method used is research and development (R&D). The development procedure is guided by the stages of the systems approach model, namely Dick & Cary's learning system development design model. This study examined the development of the PMM-BL model and its operational form to improve critical thinking skills and examines differences in students' critical thinking abilities before and after implementing the PMM-BL model.

Keywords: *Critical thinking, PMM-BL, Primary school students.*

1. Introduction

PISA 2022 data shows that Indonesia's ranking has risen 5-6 positions compared to PISA 2018. However, even though there was an increase in ranking in PISA 2022, Indonesia recorded a decrease in scores in each ability assessment subject (OECD, 2019). PISA and TIMMS questions are based on higher-order thinking Skills (HOTS), but the Indonesian curriculum has not yet fully practiced HOTS. This is the reason why PISA and TIMMS scores are always low. The government's policy to increase PISA scores began with HOTS content in the National Examination questions, before being replaced with Minimum Competency Assessment and Character Survey. However, the learning model used in the learning process, as well as the curriculum, still does not train HOTS as a whole understanding. Therefore, innovation is needed to change the curriculum with HOTS content implemented in learning and appropriate learning models (Hasyim et al., 2024). In practice in the classroom, the implementation of one level of sometimes encountered obstacles because each student in the class was different. Diversity is related to readiness, interest, learning style, and speed in receiving and processing information. In science learning, teachers usually select one type of inquiry model to be applied to all students for a particular topic (Zubaidah et al., 2017). Education in the knowledge era directs the educational process which is no longer dominated by the transfer of knowledge but is directed at involving students to be able to build and develop thinking skills with an extraordinary acceleration of increasing knowledge (Trilling, B., & Fadel, C.,2009).

* Correspondence: lita.ariyanti.2121039@students.um.ac.id

Low student achievement in Science in Indonesia has been a concern for the government, stakeholders, school principals, and parents for many years as a result of poor teaching techniques, student attitudes, lack of teaching and learning materials, teacher pedagogical skills, etc. Several studies, for example, the Monitoring Learner Achievement (MLA) project conducted by UNESCO and UNICEF, do not show an increase in the performance of Indonesian students in Mathematics and Science. Important skills that must be mastered are; critical thinking, problem-solving, creativity, innovation, collaboration, and communication. (Sharadgah, 2014). Critical thinking is defined as an individual's ability to obtain and assess information, analyze information and opinions correctly, use clear and accurate reasons, make accountable judgments, and reach thoughtful conclusions. (Bachtiar et al., 2018). States that twenty-first-century skills "include independent skills, collaborative problem solving, communication and other competencies (Greenstein, L, 2012). Critical thinking is a fundamental educational ideal that involves student independence and direction to prepare students for the future (Retno, R. S, et, al, 2022).

Critical thinking is an important element as a means of perfecting thinking skills and providing strategies to students to help them be productive in the future. (Hanurawan & Waterworth, 2004). Critical thinking ability is one of the abilities needed at this time (Al-Fadhli, S., & Khalfan, A, 2009). The importance of emphasizing thinking skills that can be put into practice in life experiences (Alami et al., 2021). One effort that can be made is to improve the quality of education provided. Observation results show that teachers have not developed learning conditions well. Thinking skills refer to the ability to think in various dimensions that are necessary for living, learning, and working; and be able to make decisions and solve problems creatively, as well as to live a normal with happiness and quality life. (Chaiyama & Kaewpila, 2022).

Teachers still monopolize learning activities by taking over the role of students, such as explaining, practicing, experimenting, telling, discussing, answering, and even attaching work. Even though ideally teachers don't need to do all that because this is the work of students and teachers are facilitators (Thamrin & Rahim, 2012). On the other hand, teachers in teaching also do not provide contextual problems to students and tend to use conventional learning based on textbooks (transferring information in books). According to (Carrió et al., 2011), problem-based learning means that students are faced with real-world problematic issues as a context for students to learn. Critical thinking is defined as an individual's ability to obtain and assess information, analyze information and opinions correctly, use clear and accurate reasons, make accountable judgments, and reach thoughtful conclusions. (Hanurawan & Waterworth, 2007). With problem-based learning that is presented typically and requires solutions will be able to make students learn and be actively involved in learning. (De Graaf & Kolmos, 2003).

The results of these two opinions, (Long & Carlson, 2011) state that problem-based learning is the beginning of learning where the problem is the point of the learning process. Creating learning in such a way that students are given real-world context problems, will make students think more critically in finding problem-solving strategies. Problem-solving through questions that act as a driving force for learning can develop students' critical thinking skills (Zubaidah et al., 2017). Critical thinking skills needed in the learning process emphasize student-centered learning. The teacher should take into account learning methods that can empower students' critical thinking skills. The teacher can use a test to observe the improvement of the student's critical thinking skills (Mahanal, S, et, al, 2017). This is certainly relevant to the researchers' initial findings where the critical thinking skills of the majority of students are still quite low. Based on the various problem findings above, efforts are needed to develop a learning model that is based on contextual problems so that it can later help students to have skills in the 21st century (critical thinking). Therefore, the problem of mind mapping-based learning can be an interesting alternative.

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Based on the study above, the model PMM-BL needs to be trialed as an alternative to improve students' critical thinking skills. Referring to several supporting theories, the implementation of the PMM-BL model to improve critical thinking skills starts with providing contextual problems to students. The PBL model is learning that results from the process of working towards understanding the resolution of problems that occur in everyday life. According to Barret, (2013). Referring to what Barret stated, integrating Mind Mapping would be very appropriate if done when presenting problems. According to Tan, (2003), at the problem presentation stage (meeting the problem) there are several things that students need to do, including individual reading, reflection, and inquiry. This is in line with what (Buzan & Lawson, 2016) Stated regarding the preparatory stages in making a mind mapping, namely reading. The purpose of reading in this context is that students are asked to read the problems presented.

PMM-BL used in teaching and learning in elementary schools provides a means for solving scientific problems, which makes students grow to think critically about their own knowledge. PMM-BL helps develop process skills, critical thinking abilities, and also students' positive attitudes toward learning in elementary school. In addition, the use of PMM-BL for science learning provides students with the opportunity to identify their strengths and weaknesses throughout the learning process. It is believed that PMM-BL is student-centered, that it prepares learners to relate scientific concepts to real-life situations, and can be adopted for science teaching and learning. The use of PMM-BL as a teaching and learning strategy can improve student performance in science if relevant factors such as teaching aids, large class sizes, subject teaching qualifications, and teaching experience can be targeted and it will have an impact on student achievement. It can be concluded that PMM-BL as a student-centered approach is effective and critical thinking in learning in elementary schools to improve student learning achievement. The purpose of this article is to improve students' critical thinking skills and the implementation of the PMM-BL Model, implementation of learning, and student activities. The PMM-BL Model is said to be practical for improving students' critical thinking skills.

2. Method

2.1. Research Design

The research method that researchers use is research and development (R&D). The development procedure is guided by the stages of the systems approach model, namely Dick & Cary's learning system development design model which is divided into ten stages as shown in the following figure (Dick, W., Carey L., & Carey, J.O, 2015).

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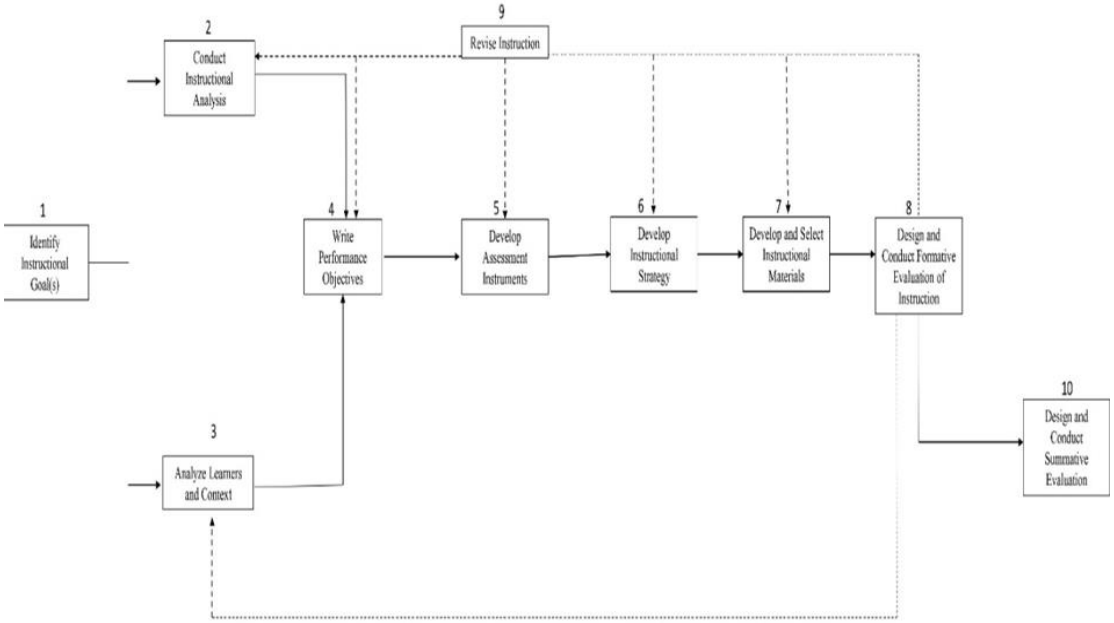

Figure 1.
The systematic design of instruction. Taken from Dick & Carey, 2015.

2.2. Procedures

Procedure for Developing a Problem Mind mapping-based Learning Integration Patterns. Next, referring to Figure 1, the following is an explanation of each stage of the systems approach model in the development model.

Identify instructional goals at this stage, the researcher carries out a needs analysis to identify the objectives of the research to be carried out. From the results of the needs analysis, it was obtained that the main aim of this research was to develop Model PMM-BL. 2) Conduct instructional analysis, Next, the researcher will carry out an analysis of the learning carried out by students in order to achieve goals, which includes the stages or steps carried out by students in implementing Model PBL-MM and sub-skills such as problem-solving required in Model PBL, as well as the reading and drawing skills needed in Mind Mapping. 3) Analyze learners and contexts, 4) Write performance objectives, by referring to the previous stage, at this stage the researcher specifically determines what students can expect to gain after completing the learning model PMM-BL, namely increasing students' critical thinking skills. 5) Developing assessment instruments, at this stage, researchers begin to develop assessment tools (instruments) that are in accordance with the specific objectives that have been previously determined, 6) Developing instructional strategies, researchers need to develop learning strategies PMM-BL Model which includes books and RPP, 7) Develop and select instructional material, at this stage, researchers develop teaching materials which will later be used as a guide for students in learning PMM-BL Model, including textbooks and LKPD. After all the instruments, strategies, and teaching materials (products PMM-BL model) developed in the fifth, sixth, and seventh stages have been implemented, then validation is carried out by experts/experts with the aim of obtaining an assessment of whether the product is Model The PMM-BL that the researchers developed has fulfilled the feasibility aspect. 8) Design and conduct a formative evaluation of instruction. 9) Revise instruction, the result of the formative evaluation carried out was that the researcher revised the product Model The PMM-BL that was developed is ready to be used again in field tests on all students.

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2.3. Product Validation and Trial

(Branch, 2009) Stated that the main purpose of field trials is to find out whether the objectives of the product being developed are achieved. The trial designs that the researchers carried out included limited trials and wide-scale trials. (Sugiyono, 2016). Meanwhile, the wide-scale trial used a one-group pretest-posttest design which can be seen in the following table.

Table 1.
Wide-scale trial design.

Pre-test	Treatment	Post-test	
O1	X	O2	Trial class

Source: (Sugiyono, 2016).

The design of a large-scale trial was carried out to determine the practicality and effectiveness PMM-BL model in a class with thirty students. Practicality of model PMM-BL will later be seen from the level of model implementation, learning implementation, and student activities. Meanwhile effectiveness PMM-BL model will be seen from the increase in critical thinking skills as measured using tests, as well as student responses measured using questionnaires.

Research subjects during the trial were limited Model PMM-BL is a class 5 student at SDN Bandulan 2 Malang City in three meetings with a total of ten students. Then, a wide-scale trial using a purposive sampling technique was also carried out at SDN Bandulan 2 Malang City in class 5 with a total of thirty students each; SDN Giripurno 2 Batu, MI Al-Fattah Malang Regency and held a total of three meetings.

2.4. Data Analysis

Analysis of PMM-BL Model Validation Data and Operational Forms, as well as Observation Sheets and Questionnaires. Validation PMM-BL model will be carried out on books and its operational forms, which consist of RPP, textbooks, LKPD, and THB, as well as observation sheets (implementation of PMM-BL Model, implementation of learning, and student activities) and questionnaires conducted by experts or experts in their field. The assessment of each product consists of four criteria, namely very valid (4), valid (3), less valid (2), and invalid (1).

$$P = \frac{\text{Number of score achieved}}{\text{Total number of aspects}}$$

The validity criteria PMM-BL model and operational forms, as well as observation sheets and questionnaires, can be seen in the following table.

Table 2.
PBL-MM model validity criteria and operational form, as well as observation sheets and questionnaires.

Score intervention	Criteria
3.6 P < 4 less4≤	Very valid
2.6 P < 3.5≤	Valid
1.6 P < 2.5≤	Not valid
1 P < 1.5≤	Invalid

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Analysis of PMM-BL Model Implementation Data. Implementability was analyzed using the following formula.

$$P = \frac{\text{Number of scores achieved}}{\text{Total number of implemetation aspects of the PBL–MM Model}}$$

As for the implementation criteria PMM-BL model in more detail can be seen in the following table. (Arsyad, 2007).

Table 3.
Criteria implementation of the PMM-BL Model.

Percentage (%)	Criteria
1.5 M 2≤≤	Done
0.5 M < 1.5≤	Partially implemented
0.0 M < 0.5≤	Not implemented

2.5. Learning Implementation Data Analysis

Implementation of learning using the PMM-BL model was analyzed using the following formula.

$$P = \frac{\text{Total scores achieved}}{\text{Total scores for all aspects of learning implementation}} \text{ x } 100\%$$

The learning implementation criteria in more detail can be seen in the following table (Hinton, P. R, 2004).

Table 4.
Learning implementation criteria.

Percentage (%)	Criteria
90.00 - 100.00	Very good
70.00 - 89.99	Good
50.00 - 69.99	Enough
00.00 - 49.99	Not good

2.6. Analysis of Student Activity Data

Student activities in implementing learning using the PMM-BL model were analyzed using the following formula.

$$P = \frac{\text{Number of students who made a particular observation category}}{\text{Number of all students}} \text{ x } 100\%$$

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The student activity criteria in more detail can be seen in the following table.

Table 5.
Student activity criteria.

Percentage (%)	Criteria
90.00 - 100.00	Very good
70.00 - 89.99	Good
50.00 - 69.99	Enough
00.00 - 49.99	Not good

2.7. Data Analysis Critical Thinking Skills

Learning outcome data in the form of critical thinking skills tests are analyzed from the scores obtained by students based on indicators of critical thinking skills which are outlined in the assessment rubric using the following formula.

$$\text{P individual} = \frac{\text{gain score}}{\text{Maximum Score}} \text{ x } 100$$

2.8. Validity Test

The validity test is used to measure whether a questionnaire is valid or not. An instrument or questionnaire is said to be valid if the questions on the instrument or questionnaire are able to reveal something that the questionnaire will measure. (Ghozali, 2018).

2.9. Reliability Test

With the decision-making criteria as stated by (Ghozali, 2018), namely, if the Cronbach Alpha coefficient is > 0.70 then the question is declared reliable, or a construct or variable is declared reliable. Conversely, if the Cronbach Alpha coefficient <0.70 then the question is declared unreliable. If made in tabular form it would be as follows:

Table 6.
Criteria reliability test.

Reliability coefficient	Criteria
> 0.90	Very reliable
0.70 – 0.90	Reliable
0.40 – 0.70	Quite reliable
0.20 – 0.40	Less reliable

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Reliability coefficient	Criteria
< 0.20	Not reliable

Table 7.
Reliability test results for critical thinking skills test items.

Variable	Cronbach's alpha	N of Items
Pre-test	0.730	5
Post Test	0.857	5

Based on the data in Table 3.7 above, the level of reliability of the listening skills test items obtained r values of = 0.730 and 0.857. Based on the reliability criteria, the listening skills test items are included in the criteria for sufficient reliability. Then, to determine the category of improvement in student learning outcomes, the critical thinking skills test scores were analyzed using the n-gain formula which refers to (Hake, 1999), namely:

$$\langle g \rangle = \frac{\langle S_{post} \rangle - \langle S_{pre} \rangle}{100\% - \langle S_{pre} \rangle}$$

The n-gain categories can be seen in more detail in the following table.

Table 8.
N-Gain value category.

N-Gain value	Category
g > 0.7	Tall
0.3 g 0.7≤≤	Currently
g < 0.3	Low

Source: (Hake, 1999).

Apart from that, the researcher also conducted a paired t-test with the help of SPSS software to determine the significance value of increasing student learning outcomes. However, beforehand it is necessary to carry out a prerequisite test in the form of a normality test to find out whether the test items are normally distributed (probability value > 0.05) or not (probability value < 0.05). The significance value used for the paired t-test isα = 0.05.
On the following bases

H_0 = There is a difference in increasing critical thinking skills for students who apply it

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PMM-BL Model.

H_1 = There is improvement difference critical thinking skills for students who apply Model PMM-BL.

3. Results

Initial product development results. At this stage the researcher identified the instructional goal, it is known that the aim of this research is to develop the PMM-BL model. After that, we continue with the conduct instructional analysis and analyze learners and contexts stages, which will be explained in detail as follows.

3.1. Examining the Curriculum Used

The step of reviewing the curriculum used is an activity carried out to find out what curriculum is being implemented and what is being implemented by the school SDN Bandulan 2 Malang City. Based on the results of interviews conducted by researchers with the Deputy Principal for Curriculum and Learning, SDN Bandulan 2 Malang City uses the 2013 Curriculum. Thematic learning has an impact on students, especially in their learning process. Students are more active in learning if the packaging of thematic learning carried out by the teacher is well planned and implemented well. Students as subjects in thematic learning activities must be well conditioned so that students must be ready to participate in learning activities that can be implemented individually, in pairs, in small groups or classically. Students must also be ready to actively participate in varied learning activities, for example through group discussions, problem solving and conducting simple research (Khofiatun, Sa'dun Akbar, 2016). This is because learning in the 2013 Curriculum uses an integrated thematic approach, especially through model webbed at the elementary school level.

3.2. Observations of Learning Implementation

After knowing the RPP that had been prepared by the fifth-grade teacher, the researcher then tried to dig up information about the implementation of learning using evaluation tools or assessment instruments for learning implementation plans belonging to the Teacher Professional Education Program (PPG). Researchers found one main problem from several aspects observed, namely:

Table 9.
Observation of learning implementation.

Aspect	Observation results
Mastery of material, namely applying the concept of learning material in life.	Teachers still monopolize learning activities by taking over the role of students, for example when explaining, practicing, experimenting, telling, discussing, answering, and even gluing on work.

Based on the observation results in the table above, it is clear that teachers still monopolize learning activities by taking over the role of students, for example when explaining, practicing, experimenting,

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telling, discussing, answering, and even gluing on work. Ideally, teachers do not need to do all of that because this is the work of students and teachers are facilitators (Thamrin dan Rahman, 2012).

3.2. Development of Assessment Instruments

Instrument evaluation developed by the researcher consists of sheet implementation observations PMM-BL model, sheet implementation observations learning, sheet observation activity students, as well student response questionnaire sheet. Development instruments the No regardless from a number of theory which underlying it, between other (1) About practicality product education, (Nieveen, 1999), argue that specification is second to educational product quality. Ifpara experts (And also professional practitioners) consider products that education is easily applied by teachers and students according to the method set by the developer. Thus, to obtain data on whether teachers and students can implement Model PMM-BL Which was developed with Correct, so instruments are required learning implementation observation sheet and student activity observation sheet, And (2) About effectiveness of product education.

3.3. Model Syntax Problem Mind Mapping -Based Learning (PMM-BL) Integration Patterns

Table 10.
Syntax PMM-BL.

Phase	Teacher activities	Student activities
First: Meeting the problem.	Form small heterogeneous groups, present contextual problems, and ask questions about the problems presented.	Commit to group roles and tasks, understand (read) the contextual problems presented, and answer questions asked.
Second: Problem analysis and learning issues.	Monitor students' involvement independently in searching for relevant information (Keywords, abbreviations, images/symbols) according to the problem focus.	Analyzing problems by constructing knowledge independently to search for information by utilizing various learning sources, such as reading textbooks, observing objects, and conducting interviews with peers or teachers. This is done by drawing a line from the central point of the Mind Mapping which will form the main branch according to the information obtained. Students can use different shapes, sizes, colors, and contrasts.
Third: Discovery and reporting.	Confirm to students the accuracy and reliability of the information obtained.	Based on the main branches that have been formed previously, students will try to find more specific information (Keywords, abbreviations, images/Symbols) to support the main branches.

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Phase	Teacher activities	Student activities
Fourth: Solution presentation and reflection.	Provide understanding or consolidation to students by reviewing and rechecking whether all concepts are connected logically and clearly, as well as clarifying doubts and misunderstandings so that the group is ready to present the results of the discussion.	Present the results of the discussion by making simple associations that describe the relationship between different concepts (keywords, abbreviations, images/symbols).
Fifth: Overview, integration, and evaluation.	Provide input and appreciation to students, together with students summarizing or concluding the material.	Provide criticism of the learning resources used, reflect on new knowledge gained, and evaluate what is done as a problem solver, independent learner, and team member.

4. Discussion

Validity of the Problem Mind mapping-based Learning (PMM-BL) Integration Patterns. The PMM-BL model was implemented in book form. The PMM-BL model received a proper assessment when validated by learning product design experts and learning material experts. Validation is carried out by referring to the following components, namely (1) Content validity, which covers development needs model PMM-BL, state-of-the-art and the rationale underlying it; (2) Construct validity, which includes objectives model PMM-BL, rationalization, and syntax Model PMM-BL, as well as the learning environment and classroom management Model PMM-BL. The score or validation value obtained was 3.54 with valid criteria.

Validity of Problem Mind Mapping-Based Learning (PMM-BL) Integration Patterns. The operational form of the PMM-BL model in the form of lesson plans, teaching materials, LKPD, and THB as learning tools received a decent assessment when validated by learning product design experts, learning material experts, and educational practitioners. Validation is carried out by referring to several components, namely content, presentation, readability, and graphics.

Validity of the Learning Implementation Plan (RPP). The RPP validation score obtained was 3.77 with very valid criteria. Based on these results, it can be concluded that the RPP developed is a suitable (good) educational product. Teaching materials The validation scores for the teaching materials obtained are 3.47 with valid criteria. Based on these results, it can be concluded that the teaching materials developed are appropriate (good) educational products. Validity of Student Worksheets (LKPD). The LKPD validation score obtained was 3.55 with valid criteria. Based on these results, it can be concluded that the LKPD developed is a suitable (good) educational product.

Validity of Learning Outcome Tests (THB). THB validation scorewhat is obtained is 3.4 with valid criteria. In connection with these results, it can be concluded that THB which was developedis a decent (good) educational product. Validity of the Observation Sheet on the Implementation of the Problem-based Learning (PBL) Model with Mind Mapping (MM) Integration Patterns. Validation value of the implementation observation sheet The PMM-BL model obtained a score of 3.6 with very valid criteria. Validity of the Learning Implementation Observation Sheet.

Practicality of the Problem Mind mapping-based Learning (PMM-BL) Integration Patterns. Implementation of the Problem mind mapping-based Learning (PMM-BL) Integration Patterns, Once

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its feasibility is known, the PMM-BL model will be implemented and measured using the PMM-BL Model implementation sheet instrument to determine its practicality based on the implementation aspects of the PMM-BL model. These eligibility criteria can be interpreted if the validator assesses that the PMM-BL model is easy for teachers to use. The average implementation model PMM-BL at SDN B, SDN G, and MI A are 1.7, 1.8, and 1.7 respectively. The total average implementation is: Model PMM-BL obtained a score of 1.7 with the criteria met.

The theory put forward by Nieveen, the results of this research also strengthen the results of research carried out by (Park et al., 2020) With the title "Study of the Practical Application of Problem-based Learning to a Major Class of Dental Hygienics: Focused on the Clinical Dental Hygienics Subject". In Park Hye-Young et al's research, it is explainedthat's it Student responses to the statement "I am actively taking this class" based on a survey regarding learning experiences using the PBL model showed a high level of satisfaction or 91.4%. These results are relevant to researchers' efforts to develop a practical PMM-BL Model and at the same time differentiate it from research conducted by Park Hye-Young et al, namely the existence of a Mind Mapping integration pattern in the PBL Model.

Learning Results Test, Once its feasibility is known, the PMM-BL model is implemented and measured using a learning outcome test instrument to determine the effectiveness of the PMM-BL model based on achieving learning objectives (students' critical thinking skills). This feasible criterion can be interpreted if the validator assesses that the desired learning objectives (critical thinking skills learners) can be achieved by applying the PMM-BL model. This shows that the average pretest score is only 44.3 and has increased after implementing model PMM-BL with a posttest score of 85.5. The average n-gain value obtained is 0.73 and is included in the high category. It is indicated if the significance value (2-tailed) is 0.00 < 0.05, so it can be concluded that it is rejected or there is a difference in learning outcomes (critical thinking skills) of students before and after implementing subcriptentin H_0 PMM-BL model. The research results achieved also confirm the theory put forward by Nieveen that the third characteristic of good quality material is that students can provide a positive response to the learning provided and the desired learning objectives can also be achieved.

The theory put forward by Nieveen, the results of this research also strengthen the results of other research, that is; 1) Research conducted by Anugraheni & Indri, (2018) with the title "A Meta-analysis of Problem-based Learning Models in Increasing Critical Thinking Skills in Elementary Schools" States that based on the results of the meta-analysis it turns out model PBL is able to improve student's critical thinking skills starting from the lowest 2.87% to the highest 33.56% with an average of 12.73%.

The results of this research are relevant to the researcher's efforts to develop an effective PMM-BL model and also differentiate it from research conducted by Anugraheni & Indri, Utomo et al, Haryani et al, (Goni & Geor, 2024), namely, a Mind Mapping integration pattern with the PMM-BL model exists. In developing an effective PMM-BL model, researchers refer to indicators of achieving the desired learning objectives: students' critical thinking skills. This is where what the researchers mean is relevant to the results of the research by (Utomo et al., 2020) and (Haryanti et al., 2022) What the researchers did, namely that the implementation of the PMM-BL model is expected to help students achieve critical thinking skills. Apart from that, by referring to the effectiveness test data, it can be seen that the average pretest score of students before implementing the PMM-BL model was only 44.3. After implementing the PMM-BL model, the average posttest score of students was 85.5. The average n-gain value obtained is 0.73 and is included in the high category. A paired t-test (paired t-test) or difference test is carried out, the results of which are obtained if the significance value (2-tailed) is 0.00 < 0.05, so that it can be interpreted if there are differences in learning outcomes (critical thinking skills) of students before and after applying the PMM-BL model.

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5. Conclusion

Based on the results of observations that have been made regarding the implementation of the PMM-BL model, implementation of learning, and student activities, the PMM-BL Model is said to be practical for improving students' critical thinking skills. The PMM-BL model is effective in improving students' critical thinking skills. Schools can integrate the PMM-BL Model into the curriculum used while still considering the management of National Education Standards (SNP). Teachers can implement the PMM-BL model while still paying attention to the characteristics of students, the characteristics of the material, and also the completeness of facilities and infrastructure.

The PMM-BL model can be implemented at the elementary/equivalent education level which has learning problems in an effort to accommodate skills in the 21st century. The PMM-BL model can be implemented with students who have a low level of critical thinking skills. Future researchers can try out the PMM-BL model to achieve other high-order thinking skills (HOTS). Future researchers can try out the PMM-BL model on different materials and subjects at the junior high, high school, or tertiary education levels.

6. Recommendations

Based on the findings and discussion of the results of this study, the recommendations that can be given are:

- The development of an integration pattern of problem mind mapping-based learning models to improve the critical thinking skills of elementary school students needs to be implemented in fifth-grade students at SDN Bandulan 2, Malang City, Indonesia in three meetings with a total of ten students.
- Then, a wide-scale trial using a purposive sampling technique, was also carried out at SDN Bandulan 2 Malang City in fifth grade with a total of thirty students each; SDN Giripurno 2 Batu, MI Al-Fattah Malang Regency, Indonesia, and held three meetings.
- Efforts to develop an integration pattern of problem-mind mapping-based learning models to improve the critical thinking skills of elementary school students need to be carried out by optimizing more varied presentation methods.
- Further research activities need to be sought to identify the the effectiveness of the PMM-BL Model based on achieving learning objectives (students' critical thinking skills)action research methods and experimental research in a broader target group.

7. Limitations

The development of an integration pattern of problem mind mapping-based learning models to improve the critical thinking skills of elementary school students is limited to:

- This study examined the development of the PMM-BL model and its operational form to improve critical thinking skills and examines differences in students' critical thinking abilities before and after implementing the PMM-BL model. This research provides basic data that can be used to develop product specifications that will be developed using the PMM-BL model to improve critical thinking skills
- The evaluation carried out in this study did not reach the (long-term) impact evaluation stage.
- Assessment of learning outcomes integration pattern of problem mind mapping-based learning models to improve critical thinking skills is only limited to cognitive aspects.

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