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The Influence of Problem Based Learning (PBL) Models Integrated Information Communication and Technology (ICT) on Mental Models in Primary School Science Learning

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Abstract: The purpose of this study is to examine the impact of the ICT integrated problem-based learning paradigm on elementary school students' mental models. When learning is done using ICT and PBL models, it will be observed if elementary school pupils' mental models grow or shrink.This study used an experimental, quantitative research design with a nonequivalent control group. 25 pupils participated in this study at SDN 08 Kampung Jawa 1 in Pariaman. The multiple choice questions used in this research tool are tests. The independent sample t-test was used in this study's data analysis. It is required to assess the conditions for data analysis, particularly the normality and homogeneity tests, before the data is studied. Based on the study's findings, a significance value (2-tailed) of 0.001 0.05 was found, leading to the conclusion that Ho is rejected and Ha is accepted, indicating that the PBL learning model's integration with ICT had a significant impact on elementary school students' mental models.

Keywords: ICT; Mental Models; PBL

Introduction

Natural Sciences (Science) is an important subject in elementary school. Science is the main capital in facing the 21st century with all the needs and challenges of its era. Facing the 21st century, competitive and scientifically literate people are needed (Prayogi & Aesthetics, 2019; Ujir et al., 2020). Science learning can provide students with the competencies needed to welcome the 4.0 era (Andriana et al., 2022; Rahayu et al., 2022). Science leads students to have skills obtained by going through stages in the form of a process of looking at natural and substantial phenomena logically and factually by conducting research, categorizing, through observations, classification, communication, and interpreting data using scientific methods (Irmawati et al., 2021; Ramdani et al., 2019). The knowledge that students have can answer problems related to natural phenomena which will always change over time. Science learning is a complex learning process. The implementation of the science teaching and learning activity process is carried out through steps that are able to foster understanding of science concepts which include macroscopic, submicroscopic and symbolic aspects (Astiti et al., 2021; Syofyan & Amir, 2019). The macroscopic aspect is a real representational aspect that can be observed directly, natural science phenomena in experiments, as well as phenomena in everyday life (Kimianti & Prasetyo, 2019; Liu et al., 2018). Submicroscopic aspects are aspects of real representation, but at the particulate level such as describing, explaining and making predictions about the concepts and principles of a natural science phenomenon. The symbolic aspect is a representational aspect to explain what is observed using models or analogies, and graphs (Avikasari1, Rukayah, 2018; Cervetti et al., 2012).

The aim of this research is to see the influence that the ICT integrated problem based learning model has on the mental models of elementary school students. It will

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be seen whether elementary school students' mental models increase or decrease when learning based on ICT and PBL models is carried out.Efforts to grow students' mental models require the ability to organize and implement actions to display certain actions (Darmiyanti et al., 2017; Suari, 2019). Mental models are concepts, frameworks, or world views that are embedded in an individual's mind in order to help him interpret the world and understand the relationships between these things (Haliq et al., 2020; Yoni et al., 2019). A mental model can also be said to be a representation of how the world works. One view of human reasoning is that it relies on mental models (Aini et al., 2019; Darmiyanti et al., 2017). According to this theory, mental models can be created by perception, creativity, or discourse comprehensionThe structure of such mental models is akin to the structure of the situation they reflect, like architects' models or physicists' diagrams, in contrast to the structure of logical forms utilized in formal rule theories of reasoning. They are comparable to Ludwig Wittgenstein's 1922 explanation of his deep picture theory of language (Ariani et al., 2020). argumentation theory based on mental modelsindividuals who hold the belief that mental models rather than logical form underlie reasoning (Suari, 2019; Yoni et al., 2019).

To see the condition of students' mental models in elementary schools, researchers conducted a preliminary study in elementary schools. The results of a preliminary study conducted through interviews on 18-23 January 2023 at SD N 08 Kampung Jawa 1 with teachers found that children were less interested in learning science because students believed that science was difficult to understand and boring to learn.Students' understanding of science concepts is only in the macroscopic aspect. Macroscopic questions can be answered correctly by 91% of students. Meanwhile, submicroscopic questions could only be answered correctly by 46% of students. Likewise with symbolic questions, only 30% of students can answer correctly. This is because the learning process only focuses on macroscopic aspects. Meanwhile, the submicroscopic and symbolic levels receive less appreciation from students. So students are less able to understand concepts and unable to solve science problems. Initial observations obtained the minimum criteria score for science lessons used at SD N 08 Kampung Jawa 1 Kota Pariaman, namely 75. The students' science learning outcomes were classified as low, namely in the percentage of 43, 75% or approximately 21 students have completed the Minimum Requirements criteria. Students do not achieve grades because they have difficulty learning science. Taking a closer look at the analysis of learning outcomes, complex multiple choice questions with a maximum score of 4 were obtained by 0% of students. Meanwhile, score 3 was obtained by 26%, score 2 was obtained by 35%, and score 1 was obtained by 39%. Likewise, on the matching choice questions, 17% of students did not answer at all and 31% answered all wrong answers. This indicates the low level of students' mental models. Meanwhile, score 3 was obtained by 26%, score 2 was obtained by 35%, and score 1 was obtained by 39%. Likewise, on the matching choice questions, 17% of students did not answer at all and 31% answered all wrong answers. This indicates the low level of students' mental models. Meanwhile, score 3 was obtained by 26%, score 2 was obtained by 35%, and score 1 was obtained by 39%. Likewise, on the matching choice questions, 17% of students did not answer at all and 31% answered all wrong answers. This indicates the low level of students' mental models.

The poor learning outcomes of the pupils, which were associated with their mental models, led to the conduct of this study. Students do not sufficiently hone and interact with this mental model in the classroom. It is anticipated that this research will have a significant impact on students' mental models. This is predicated on pupils who are less enthused and motivated to study science. In this study, the PBL learning paradigm was applied and combined with ICT in the hopes that it would enhance students' cognitive capacities and mental models and make science lessons in the classroom very engaging. Students' lack of initiative and discernment in selecting the best course of action to address their learning challenges is another factor driving this research. Because they are still reliant on one another and do not study independently, students' mental models are not entirely developed.

Given these problems, researchers are interested in fixing existing problems. Researchers use a learning model that is integrated with technology, because 21st century learning is currently very close to technology. The integration of PBL and ICT has several benefits, including being able to solve problems and make the learning process better because learning via computers is fun for students and teachers (Chitnis, 2017; Gössling, 2018; Isnaeni et al., 2021). ICT integrated with PBL can increase students' knowledge retention (Kristinawati et al., 2018; Newhouse, 2017; Scholkmann, 2017). The use of ICT offers several benefits, including the capacity to access information quickly, precisely, and without regard to place or time, which makes it possible to help the teaching and learning process (Bedregal-Alpaca et al., 2019; Nirbita et al., 2018; Tania et al., 2020). We are beginning to see some of these benefits, and the government is making an effort to raise educational standards based on technology by developing policies to improve educational access, effectiveness, efficiency, and quality as well as educational management through the use of ICT (Fernández-Gutiérrez et al., 2020; Sanchez et al., 2019). This makes the integration of ICT into science education increase students' abilities to solve issues under real-world circumstances and learn to memorize within the bounds of the subject (Fetaji, 2018; Krause et al., 2017; Lindberg et al., 2017). The teacher's contribution to learning can influence the achievement of the students. The aforementioned issues can be resolved by teachers who have the capacity to plan and carry out instruction.

Teachers must direct learning by implementing teaching strategies that can offer opportunities and motivate students to think critically. The ability to think critically is demonstrated by students' ability to analyze and find solutions to science problems in everyday life so that they can understand the concepts of science learning better and more meaningfully. The reality is that teachers have not packaged lessons well, the environment is not appropriate, learning is not fun, and student involvement in learning is still low. ICT has become an important part and really supports the implementation and success of learning activities in education. One of the benefits of using ICT media is that it can improve the quality of education because you can easily receive information from anywhere. ICT can help to make information or knowledge accessible more easily and more widely. Currently there are many media available to bridge information such as journals, e-books, articles, and digital libraries. ICT in education can play two different roles: (1) as a medium for learning presentations, such as PowerPoint slides and flash animations; and (2) as an independent learning medium or E-Learning, such as giving students reading or internet research assignments. It is envisaged that the usage of learning media would enable teachers to play a more creative and effective role in how they present the information to their students in the classroom. The use of ICT in educational media is anticipated to significantly impact and innovate the field of education (Ismaili, 2020; Siddiquah & Salim, 2017; et al., 2020).

Method

Experimental and quantitative approaches are used in this work. Quantitative research uses methods to assess particular hypotheses by examining the relationships between variables This study uses a nonequivalent control group design because it is a quasi-experimental study. Quasy experimentation is research that uses an experimental unit within the parameters specified in the experimental class to produce data that represents what is expected in an attempt to learn from experiments (Rusydi & Fadhli, 2018). The nonequivalent control group design is as Table 1.

Table 1. Nonequivalent Control Group Design

Group	Pretest	Treatment	Posttest
Experiment	O1	X	O2
Control	O3	-	O4

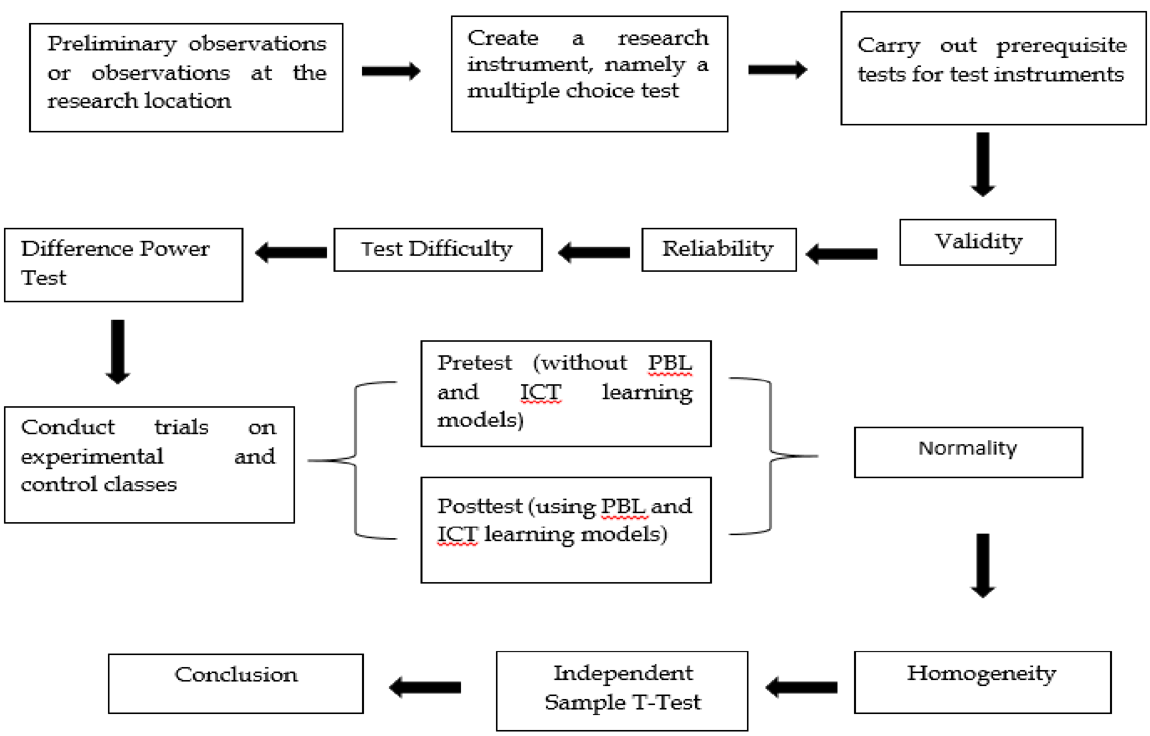

Figure 1. Research Flow

The participated were 25 pupils in this study at SDN 08 Kampung Jawa 1 in Pariaman. Children in Cluster I, Central Pariaman District, Pariaman City, who were enrolled in fifth-grade elementary schools during the 2022–2023 academic year made up the study's population. A non-probability sampling technique is used by technical researchers to choose samples, meaning that not every member of the population is given the same chance or opportunity to be selected as a sample (Gainau, 2021). These research tool's multiple-choice questions are tests. The data analysis for this study made use of the independent sample t-test. Prior to studying the data, it is critical to evaluate the conditions for data analysis, especially the normality and homogeneity tests. To perform the t test, the data distribution needs to be uniform and normally distributed (Hidayanti et al., 2019). The following is the flow of this research.

Result and Discussion

The research instrument that will be used to obtain data will first be tested. This is done to determine the suitability of the instruments that will be used in the research. Instrument trials were given to 23 students in class V of SD 19 Kampung Baru Kota Pariaman and this school is not a research sample, the data is used to obtain results in the instrument testing that will be carried out. The research instrument was tested to determine the quality of the test, namely through testing validity, reliability, distinguishing power and level of difficulty.

Validity test

Before carrying out a pretest on students, researchers first validate or test the questions on students. Before the researcher gave pretest and posttest questions to students, the researcher first validated them with experts in their field and the results found that the test was valid and declared appropriate after being checked by the validator. After conducting a validity test with experts, the researcher tested the pretest questions using SPSS 21. In accordance with valid rules, the questions will be declared valid if rcount > rtable. By looking at the table, if we take 23 respondents using α = 0.05 then rtable = 0.413. From the results of validation calculations using the Product Moment Correlation formula, it turns out that of the 25 questions tested there were valid and invalid questions, 20 questions were declared valid, while there were 5 questions that were declared invalid. The calculation results are obtained as Table 1.

Table 1. Validation Test Results

Question item number	Information
1, 2, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 19, 20, 21, 22, 24, 25	Valid
3, 6, 15, 18, 23	Invalid

Reliability Test

After examining the validity test findings, reliability calculations were performed on the test instrument, which was composed of 25 multiple-choice questions. The alpha formula, which describes the degree of reliability of something, is applied in this reliability test. Reliable means dependable and trustworthy. The query is deemed questionably reliable if rcount exceeds rtable. The Table 2 contains the findings of the SPSS 21 reliability test.

Table 2. Reliability Test Results

Reliability Statistics	
Cronbach's Alpha	N of Items
.693	25

Based on the reliability data above, it can be seen from Cronbach's Alpha that the rcount value > sig. 0.05 at α = 5% with n = 23 respondents, obtained 0.693 > 0.05 so the question is said to be reliable.

Test the Difficulty Level of Questions

The 25 things that were put to the test ranged in difficulty from easy to difficult, according to the results. The exam items known as medium criterion, precisely 14 questions, were determined based on data computations on the question instrument. 9 questions make up the test components referred to as easy criteria, while 2 questions make up the difficult criterion. The Table 3 shows the test results for the questions' degree of difficulty.

Table 3. Test Results for Question Difficulty Levels

Question Item Number	Information
1, 3, 5, 6, 11, 13, 16, 17, 20	Easy
2, 4, 7, 8, 9, 10, 12, 14, 15, 19, 22, 23, 24, 25	Currently
18, 21	Hard

Difference Power Test

Calculations are done to determine the questions' ability to differentiate themselves after determining their level of difficulty. Based on data computations on the question instrument, the results showed that of the 25 questions evaluated, 4 fell into the "good" category, 16 fell into the "sufficient" category, and 5 fell into the "poor" category. The Table 4 shows the outcomes of the various power tests.

Table 4. Results of Different Power Test Questions

Question Item Number	Information
8, 12, 15, 24	Good
1, 2, 3, 4, 5, 6, 7, 9, 10, 14, 16, 19, 20, 21, 22, 25	Enough
23, 11, 13, 17, 18,	Not enough

The hypothesis test is then performed after the prerequisite questions have been examined. Tests for homogeneity and normalcy should be performed initially. Table 5 shows the results of the normality test for the experimental class and control class.

Table 5. Normality Test for Experimental Class and Control Class

Tests of Normality						
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.
Control	.122	25	.200*	.832	25	.078
Experiment	.071	25	.200*	.875	25	.156

The results of the normality test were significant at or above 0.05 for the experimental class (0.156 > 0.05), while they were significant at or above 0.05 for the control class (0.078 > 0.05), as shown in the aforementioned table.Thus, the distribution of the students' mental model scores in the experimental class and the control class can be regarded to be regular. If the data from both the experimental class and the control class are normally distributed, the homogeneity test is the next step. To ascertain whether the data are homogeneous or have the same variance, the homogeneity test is utilized. According to the homogeneity test reference, the data have the same homogeneous variance if the significance value is more than 0.05. The variance of the data is uneven or heterogeneous if the significance threshold is less than 0.05. The results of the homogeneity test for the experimental class and control class are displayed in the Table 7.

Because the homogeneity test for the experimental class and control class yielded a significance value of 0.085 or greater than 0.05 (0.085 > 0.05), statistical levee of 3.745, it is possible to infer from the above table that the experimental class and control class data have the same or homogeneous variance. The justification above makes it obvious that the homogeneity test and normality test requirements have been met. The validity of the hypothesis is next examined using the t test. In order to compare posttest outcomes between the experimental class using PBL and ICT and the control class using traditional learning, the independent sample t-test is used in this study's data analysis. The goal of this study is to ascertain whether the PBL learning model combined with ICT has a significant impact on the mental models of primary school students. The independent sample t-test was run using SPSS, and the results are displayed in the Table 8.

Table 7. Test the homogeneity of the experimental class and the control class

Test of Homogeneity of Variances			
Students' Mathematical Disposition			
Levene Statistics	df1	df2	Sig.
3.745	1	48	.085

Table 8. Independent sample t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Student Mental Models	Equal variances assumed	3.745	.085	-4.362	48	.001	-14.635	2.281	-17.599	-6.585
	Equal variances not assumed			-4.362	48	.001	-14.635	2.281	-17.599	-6.585

Given that Ho is disregarded and Ha is accepted based on the above table's significance value (2-tailed) of 0.001 0.05, it can be concluded that the integration of ICT into the PBL learning paradigm significantly affected the mental models of elementary school students. The findings of the analysis and calculation of the data on the mental models of experimental class students who got PBL-ICT model therapy and the mental models of control class students who received traditional learning treatment revealed discrepancies. In terms of the average score between the two classes, the experimental class outperformed the control class. As a result, PBL-ICT learning has a bigger effect on elementary school students' mental models.

This is due to the fact that the PBL model has numerous advantages when it comes to implementation, including involving students in learning activities to ensure that their knowledge is thoroughly absorbed, preparing students to work collaboratively with other students, and enabling students to learn problem solving from a variety of sources (Budiyono et al., 2020; Nofziarni et al., 2019). The advantages of PBL include motivating students to be able to solve problems in real-world situations, enabling students to develop their own knowledge through learning activities, focusing learning on problems rather than unrelated material, having students participate in scientific activities through group work, and accustoming them to using knowledge sources from the library, internet, interviews, and observations. Participants said the PBL approach has enhanced their capacity to collaborate as a group, have the self-assurance to express their opinions, be more engaged, have better communication skills, and demonstrate more critical thinking after just one session (Korpi et al., 2019; Kristinawati et al., 2018; Lee & Blanchard, 2019).

Currently, various types of media are used in the problem based learning model, such as animation, audio visual, PowerPoint, Edmodo, Geogebra, and the use of digital media (Tania et al., 2020).This supports the integration of the PBL model with ICT.According to UNESCO, Information and Communication Technology (ICT) is technology used to communicate and create, manage and distribute information. ICT typically refers to devices like computers, the internet, phones, televisions, radios, and other audiovisual components. (Liesa-Orús et al., 2020; Rubach & Lazarides, 2021). Information technology and communication technology are two components of ICT. Information technology includes all procedures, tool usage, information manipulation, and information management. Meanwhile, communication technology encompasses all techniques for handling and transferring data between devices (Asrizal & Utami, 2021; Marfiana & Ramadan, 2021).

ICT essentially serves the purpose of facilitating human activity by implementing technology and information systems. ICT can be used for a number of things, such as: enhancing the standard of goods and services. ICT may expedite and improve the teaching and learning process in the realm of education (Lawrence & Tar, 2018). The availability of academic information services for educational institutions, the provision of data search engine facilities, the provision of discussion facilities, and the provision of good information network facilities are additional advantages of ICT in the educational sector (Chitnis, 2017; Isnaeni et al., 2021). ICT has become an important part and really supports the implementation and success of learning activities in education. One of the benefits of using ICT media is that it can improve the quality of education because you can easily receive information from anywhere (Kristinawati et al., 2018; Sanchez et al., 2019).

In this study, student-centered learning combined with the BPL-ICT learning model significantly impacted how well students' knowledge and abilities, particularly their mental models, were developed. Following the implementation of learning using the PBL approach that was coupled with ICT, students' mental models dramatically improved. This is corroborated by earlier research, which shows that applying the PBL approach can improve learning results and student motivation (Isnaeni et al., 2021; Kristinawati et al., 2018). Students are joyful while learning since the material is relevant to their everyday life. Additionally, students start to learn how to use basic technology and enjoy ICT learning. Students find this learning to be very relevant since it creates a positive impression without diluting the scientific content that is intended to be learned. Future studies, however, can expand on this study in the area of ICT proficiency in primary school-aged children.

Conclusion

The application of the integrated problem-based learning model of information and communication technologies has a substantial impact on the mental models of the fourth grade elementary school children.The usage of the PBL learning paradigm in conjunction with ICT has a substantial impact on elementary school students' mental models, as can be inferred from the discussion above, leading to the conclusion that Ho is rejected and Ha is accepted. The two-tailed significance value for this finding is 0.001 0.05. The findings of the analysis and calculation of the data on the mental models of experimental class students who got PBL-ICT model therapy and the mental models of control class students who received traditional learning treatment revealed discrepancies. In terms of the average score between the two classes, the experimental class outperformed the control class.

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