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PROBLEM-BASED LEARNING MODEL AND DISCOVERY LEARNING MODEL BY LEARNING MEDIA: STUDENTS' CREATIVE THINKING AND MATHEMATICAL COLLABORATION SKILLS

Mardawati[1], Agustan[2], Rukli[3]
[1, 2, 3] Universitas Muhammadiyah Makassar, Indonesia

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ABSTRACT

This study intends to determine whether there is a difference in the creative thinking and mathematical collaboration abilities of students with the problem-based learning model and discovery learning model by learning media. The type of research used is quasi-experimental, a nonequivalent control group design. The research sample was 58 students from two elementary schools using the cluster random sampling technique. The data collection technique was carried out using a test and observation sheet, which were analyzed descriptively. The findings of the study indicated that (1) there is a difference in the creative thinking abilities of fourth-grade elementary school students between students taught the problem-based learning model and the discovery learning model. This finding is based on the results of the Paired-Sample T-Test analysis, which obtained a Sig value of 0.028 < 0.05. (2) There is a difference in the ability of fourth-grade elementary school students to collaborate in mathematics between students taught by the problem-based learning model and the discovery learning model. This is based on the results of the Paired-Sample T-Test analysis, which obtained a Sig value of 0.001 < 0.05. (3) For fourth-grade students, problem-based learning has a greater impact on their creative thinking and collaboration abilities compared to the discovery learning model. This is based on the results of the MANOVA analysis, which obtained a significant value of creative thinking ability showing 0.040 < 0.05 and a significant value of collaboration ability showing 0.001 < 0.05, so it can be concluded that H0 is rejected, and Ha is accepted.

Corresponding Author:

Mardawati,
Universitas Muhammadiyah Makassar, Indonesia
Email: mardawati55@gmail.com

1. INTRODUCTION

Mathematics is a basic science that is general or universal in nature, where its learning influences and is related to other sciences (Serra, 2023). The purpose of learning mathematics is to train students' logical, analytical, systematic, critical, innovative, and creative abilities as well as the ability to work together (Deisenroth et

al., 2020). 21st-century learning is characterized by learning skills and literacy that require students to have four competencies called 4C (Herlinawati et al., 2024). These competencies include critical thinking and problem-solving skills, creativity skills, communication skills, and collaboration. This aligns with Amiruddin et al. (2023) view that national education prioritizes 21st-century learning, with a focus on student-centered learning through the Student Center. Therefore, learning carried out with the Student Center is able to train students to be more creative and flexible in solving problems.

Creativity is closely related to thinking; if you don't think about how to become a creative individual. So, an individual must think first before coming up with something creative. Avcı & Durak (2023) defines creativity as a product of creative thinking. In thinking, a person will go through the stages of synthesizing ideas, building ideas, planning the implementation of ideas, and implementing these ideas to produce something or a new product. Based on the previous description, it shows that the ability to think creatively is a very important competency in today's modern society because it can make humans more flexible, open, and easy to adapt to various global situations and conditions. Furthermore, according to Jaelani et al. (2023); Habib et al. (2024), the ability to think creatively is a person's ability to think so that they are able to provide different ideas that can then be used as new knowledge that is needed. Thus, creative thinking is very necessary in solving a problem (Suherman & Vidákovich, 2022). Creative thinking means having the ability to solve problems by trying to create new ideas, or it can also be interpreted as a mental activity that someone uses to build new ideas or thoughts. Creative thinking skills are related to how students build new ideas that are connected to previously held understanding in solving problems (Hsia et al., 2021; Dilekçi & Karatay, 2023).

In addition, 21st-century skills focus on critical learning skills and innovation. One of these skills is collaboration skills (Thornhill-Miller et al., 2023). This ability can improve students' skills in the 21st century. Collaboration skills are a continuous process of interaction between several people. Collaboration has become an important skill to achieve effective results. Through collaboration, students have the ability to work together, and there is interaction between students to achieve learning goals (Hussein, 2021). Based on the description of creative thinking and collaboration skills, it is very useful and important for students to apply and use them in the 21st century.

However, based on a preliminary study conducted by researchers on grade IV teachers of elementary school, it was conveyed that creative thinking and collaboration skills were still relatively low; during the learning process, students had difficulty expressing their opinions, which only followed the opinions of other friends who were smarter. In addition, student activities in groups were not fully implemented well, had not been maximized in carrying out collaboration skills, students still had difficulty in completing group assignments that were part of them on time, had not been active in conveying ideas when discussing in groups, were lazy to find learning resources to complete the tasks given, had difficulty in making conclusions from an activity, and lacked confidence in making presentations in front of the class. During the interview,

the researcher also obtained students' daily test scores in mathematics with an average score not far and significantly from the minimum completion criteria, which is 70.

The students' creative thinking and collaboration abilities are low, one of which is due to the implementation of learning models that are still conventional so that students are less interested in learning, lack of interaction between teachers and students, and lack of student cooperation in discussions (Ramadhani et al., 2020; Yaniawati et al., 2020). This view is in line with the opinion of Chen et al. (2022), who stated that one of the causes of the lack of students' creative thinking abilities is learning that is less interesting and challenging. As a result, students experience a decline in learning outcomes, making it difficult for them to achieve the intended learning objectives. Therefore, a solution is required to address this issue.

An alternative to overcome the low creative thinking and collaboration abilities of students is that teachers need to choose and apply innovative learning models that are in accordance with the subject matter (Ramadhani et al., 2020; Yaniawati et al., 2020). Learning can foster the development of ideas, the ability to argue, the ability to communicate, and the ability to solve problems. In this study, researchers adjust learning models that can be used as solutions to improve creative thinking and collaboration skills, namely implementing problem-based learning models and discovery learning models.

It is possible for students to learn better skills and be more involved in the process through the problem-based learning model (Anggraeni et al., 2023). This is because it starts with a real problem that students have to solve through investigation and using a problem-solving approach (Ghani et al., 2021; Muzaini et al., 2022; Hasbi & Fitri, 2023). In addition, the PBL model is designed to develop students' ability to solve problems and requires full student involvement activities; it can stimulate students' thinking and help them develop learning independence while learning with their groups (Aslan, 2021; Satriani et al., 2021). Problem-based learning accustoms students to develop their mindset in solving problems so as to foster creativity.

Meanwhile, the discovery learning model is learning that directly involves students in finding concepts or answers to problems that have been oriented (Ozdem-Yilmaz & Bilican, 2020). In discovery learning, the teacher only acts as a facilitator and guide in finding these concepts to avoid knowledge deviation so that students make their own discoveries, which makes learning more meaningful (Honomichl & Chen, 2012). Direct involvement of students in problem solving can improve students' creative thinking skills because solving a problem must bring up new ideas from within the students, thus requiring them to think creatively.

The effectiveness of the above model is proven by several research results, such as that conducted by Elizabeth & Sigahitong (2018), that students' problem-solving creativity in creative thinking increases due to the application of learning with the problem-based learning model. Research by Fitriyani et al. (2019) says that the use of the PBL model can improve students' collaboration and high-level thinking skills. Furthermore, research by Sohilait (2021) states that learning that can improve students' creative thinking skills is the discovery learning model.

Today, the rapid advancements in science and technology encourage students to quickly adapt and follow these developments. The development of technology has a significant influence on the development of education in elementary schools, so the use of learning tools and media is highly recommended (Timotheou et al., 2023). Therefore, teachers should use varied and memorable models in learning media to develop students' mindsets (Komariah et al., 2018). The learning media used in this study are mobile learning media and visual media.

Mobile learning is an alternative for developing learning media (Korucu & Alkan, 2011; Sunismi, 2015). Mobile learning allows students to carry out activities in the form of accessing learning materials, directions, and learning information anywhere and anytime without being limited by space and time. Mobile learning is able to overcome the limitations of time allocation for certain materials and train students to learn independently from various sources provided (Criollo-C et al., 2021). Meanwhile, visual media is a learning medium that can help teachers convey contents or learning materials using the sense of sight (Fuady & Mutalib, 2018). The use of visual media also helps students in learning because by using media, students' minds will be more focused on the efforts conveyed by educators and can improve students' understanding in the learning process (Liono et al., 2021).

The difference between this study and previous studies lies in the implementation of the model and media used. This study compares two learning models by integrating e-learning and visual-based learning media to determine the differences in students' creative thinking abilities and collaboration abilities. Therefore, further research is required to identify these differences.

The idea behind the study and the preliminary study were used to help the researcher find out how using the problem-based learning model with mobile learning media compared to the discovery learning model with visual media affected the creative thinking and teamwork skills of fourth-grade students in Limboro District, Polewali Mandar Regency. This will allow for more relevant and accurate research.

2. METHOD

This type of research is experimental research. The form of experimental design uses a quasi-experimental design. The research design used is a non-equivalent control group design. In this design, both groups will be given a pretest before carrying out the learning treatment and a posttest after carrying out the learning treatment with a problem-based learning model assisted by mobile learning and a discovery learning model assisted by visual media. Table 1 presents the following non-equivalent control group design.

Table. 1 Non-equivalent Control Group Design

Group	Pre-test	Treatment	Post-test
Experiment 1	O_1	X1	O_2
Experiment 2	O_3	X2	O_4

The data sources in this study are divided into two, namely primary and secondary data. The primary data sources in this study were grade IV students at elementary school

008 Camba-camba and grade IV students at elementary school 010 Palece. The study primarily used creative thinking ability tests and observation sheets to assess the mathematics collaboration abilities of grade IV students from elementary school 008 Camba-camba and grade IV students from elementary school 010 Palece. The secondary data sources in this study were data from the same grade IV students mentioned earlier, articles, journals, and related literature. The following is a sample in this study with a total of 58 people presented in Table 2.

Table 2. Research Sample

No	School Name	Class	Number of Students
1	Elementary School 010 Palece	IV	29
2	Elementary School 008 Camba-camba	IV	29
	Total		58

This study uses observations and tests as data collection techniques. The written test used in this study is a descriptive question to measure and determine the increase in students' creative thinking abilities. We used both descriptive and inferential analysis to look at the information from the creative thinking test and the observation sheet about how well students in experimental groups 1 and 2 worked together on math problems.

The learning device instruments in this study consisted of a) lesson plans for problem-based learning models. b) Lesson plan for discovery learning models. c) Student worksheets. Additionally, we utilized the Creative Thinking Ability Test instrument. Table 3 presents the written test, which includes descriptions with indicators of creative thinking abilities.

Table 3. Creative Thinking Ability Indicators

Indicator	Criteria
Fluency	Providing ideas correctly and appropriately
Flexibility	Solving questions in more than one way
Originality	Students can provide unusual answers, different from others
Elaboration	Detailing answers to questions correctly and appropriately

Table 4 below presents the observation guidelines for measuring students' collaboration abilities using four collaboration ability indicators.

Table 4. Collaboration Capability Indicators

Indicators	Observation Criteria
Willing to form heterogeneous groups	Students accept to enter the predetermined group
	Students are in groups during the discussion process
Each member works together and complements each other to solve problems and generate ideas	Students discuss in groups to solve problems in student's worksheet
	Students express opinions and ideas during discussions
	Students help friends while working on student's worksheet
Responsible for carrying out group assignments that are part of it.	Students present their completed assignments in front of the class

Indicators	Observation Criteria
	Students ask other groups about assignments or materials that they have not understood
	Students look for learning resources for fraction material to solve problems in the students' worksheet
	Students complete their group assignments on time
Able to make decisions by considering common interests	Students choose one member of the group as the leader.
	Students ask for ideas and opinions from group members in making decisions.

To find out whether the research instrument is suitable for use and meets the requirements for data collection, first conduct a validity and reliability test. The instrument can measure the desired variables if it meets the appropriate and adequate requirements. We will use the results of the research instrument trial to assess its feasibility before implementation. The trial was carried out in Class IV elementary school 031 Banu-Banua with the aim of perfecting the research instrument before being used in implementation. The data from the creative thinking ability trial obtained were processed to determine the quality of the instrument by determining the validity, reliability, discriminatory power, and level of difficulty of the questions.

We used descriptive analysis techniques and inferential analysis techniques to analyze the data. The goal of descriptive analysis is to describe the creative thinking and math teamwork skills of class IV. It uses the sample size, ideal score, maximum score, minimum score, score range, average (mean), median, mode, standard deviation, and variance to do this.

Inferential statistical analysis was carried out by several tests that would test the research hypothesis. We used the MANOVA test to test the hypothesis. Before testing the hypothesis, a prerequisite test was first carried out, namely, a normality test, a homogeneity test, a test for homogeneity of the variance-covariance matrix/box M, and a multicollinearity test. Furthermore, testing the research hypothesis involves using the T-Test and MANOVA. To determine the differences in creative thinking and mathematical collaboration abilities of students taught with the problem-based learning model assisted by mobile learning media and those taught with the discovery learning model assisted by visual media.

3. RESULTS AND DISCUSSION

Results

Description of creative thinking and mathematical collaboration skills of fourth grade students

We conducted this study on fourth-grade students from an elementary school in Limboro District, Polewali Mandar Regency. We used an experimental design to describe the students' creative thinking and mathematical collaboration abilities after treatment. The study was conducted based on the results of student tests and reviewed

indicators of creative thinking abilities, specifically First, production (fluency) is the ability to produce many ideas. Second, flexibility is the ability to propose various approaches and solutions to problems. Third, originality is the ability to produce original ideas as a result of one's own thoughts and not clichés. Fourth, elaboration is the ability to describe something in detail. The following describes the results of the analysis based on the results of student tests.

We found that fourth-graders at an elementary school in Limboro District think creatively at different levels. The creative thinking of students in experimental group 1 was different in terms of fluency, flexibility, originality, and elaboration. In the very creative category, there are 27 students out of a total of 29, or 93%. In the creative category, there are 2 students, or 7%, and in the fairly creative, less creative, and not creative categories, there are 0 students. It can be said that the fluency component is in the very creative category to be able to provide ideas correctly and appropriately, flexibility in solving questions in more than one way, the originality of students can provide unusual answers, different from others, and elaboration in detailing the answers to questions correctly and appropriately.

The level of creative thinking of fourth-grade students at Limboro District Elementary School, based on the results of the study in Experimental Group 2, has different characteristics in terms of indicators of fluency, flexibility, originality, and elaboration. In the very creative category, there are 24 students, or 83%; in the creative category, there are 5 students, or 27%; and in the fairly creative, less creative, and not creative categories, there are 0 students. It can be said that the fluency component is in the very creative category to be able to provide ideas correctly and appropriately, flexibility in solving problems in more than one way, students' originality can provide unusual answers, different from others, and elaboration in detailing answers to questions correctly and appropriately.

Furthermore, research results from experimental group 1 showed that 72% of fourth-grade students from Limboro District Elementary School met the criteria for being very collaborative, which included 21 students. In the collaborative category, 8 students, or 28% of the total, met these criteria. Therefore, it can be concluded that the average collaborative ability of students meets the indicators, namely being willing to form heterogeneous groups, each member working together and complementing each other to solve problems and produce ideas, being responsible for working on group assignments that are part of them, and being able to make decisions by considering common interests.

The level of collaboration ability of fourth-grade students of Limboro District Elementary School based on the results of research in experimental group 2 showed that there were 13 out of 29 students who met the criteria for being very collaborative, or 44%. Meanwhile, in the collaborative category, there are 12 students who meet the criteria, or 41%. Four pupils, or 13% of the total, fit the requirements in the fairly collaborative category. Therefore, it can be concluded that the average collaborative ability of students meets the indicators, namely being willing to form heterogeneous groups, each member working together and complementing each other to solve

problems and generate ideas, being responsible for working on group assignments that are part of them, and being able to make decisions by considering common interests.

Differences in data on creative thinking and mathematical collaboration skills of fourth grade students

The analysis is based on the results of statistical tests using MANOVA (Multivariate Analysis of Variance). The average score is based on the dependent variable (Creative Ability and Collaborative Ability) and the independent variables (Problem-Based Learning and Discovery Learning). The results are shown in Table 5: Descriptive Statistics. The average value of creative ability with the problem-based learning treatment is 89.48, and the average value of creative ability with the discovery learning treatment is 85.62. Meanwhile, the average value of collaboration ability with the problem-based learning treatment is 81.28, and the average value of collaboration ability with the discovery learning treatment is 72.86.

Table 5. Descriptive Statistics

	Experiment	Mean	Std. Deviation	N
Creative_Ability	Problem Based Learning	89,48	6,869	29
	Discovery Learning	85,62	7,113	29
	Total	87,55	7,199	58
Collaborative_Ability	Problem Based Learning	81,28	8,460	29
	Discovery Learning	72,86	9,749	29
	Total	77,07	9,993	58

Furthermore, the results of Table 6 Multivariate Tests show three numbers giving P values for four different multivariate tests, namely Pillai's Trace P value = 0.188, Wilks' Lambda P value = 0.812, Hotelling's Trace P value = 0.231, and Roy's Largest Root P value = 0.231. If 4 p-values show <0.05, then it is significant at the 95% confidence level.

Table 6. Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[c]
Intercept	Pillai's Trace	,994	4518,452[b]	2,000	55,000	,000	9036,904	1,000
	Wilks' Lambda	,006	4518,452[b]	2,000	55,000	,000	9036,904	1,000
	Hotelling's Trace	164,307	4518,452[b]	2,000	55,000	,000	9036,904	1,000
	Roy's Largest Root	164,307	4518,452[b]	2,000	55,000	,000	9036,904	1,000
Experiment	Pillai's Trace	,188	6,350[b]	2,000	55,000	,003	12,699	,884
	Wilks' Lambda	,812	6,350[b]	2,000	55,000	,003	12,699	,884

Effect		Value	F	Hypothesis df	Error df	Sig.	Noncent. Parameter	Observed Power[c]
	Hotelling's Trace	,231	6,350[b]	2,000	55,000	,003	12,699	,884
	Roy's Largest Root	,231	6,350[b]	2,000	55,000	,003	12,699	,884

The results of Table 7 Levene's Test of Equality of Error Variances show a Sig. value of 0.843 where > 0.05 creative ability and a Sig. value of 0.636 where > 0.05 collaborative ability. If the Sig. value is greater than 0.05, then all variables have the same variance. These results show that all dependent variables have the same variance because the Sig. value is greater than 0.05.

Table 7. Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Creative_Ability	,040	1	56	,843
Collaborative_Ability	,226	1	56	,636

On the other hand, the MANOVA test results show that all of the independent variables (problem-based learning, discovery learning, and how problem-based learning and discovery learning interact) have an effect on the dependent variable (creative ability and collaborative ability). If the significance (Sig.) value is less than 0.05, it is considered significant. Both sig. values are <0.05, so it can be said that the model is valid. Also, to find out if there is a difference between students who are taught the problem-based learning model with the help of mobile learning media and those who are taught the discovery learning model with the help of visual media in how well they can work together to solve math problems and think creatively. Based on the results of the MANOVA analysis, the significant value of creative ability shows 0.040 where <0.05, and the significant value of collaboration ability indicates 0.001 where <0.05. Therefore, we reject H0 and accept Ha. The experimental group (problem-based learning and discovery learning) significantly affects students' creative abilities with a P value of 0.040. With a P value of 0.001, the experimental group (problem-based learning and discovery learning) had a significant impact on students' ability to collaborate. It can be said that students who were taught the problem-based learning model with the help of mobile learning media and those who were taught the discovery learning model with the help of visual media have different levels of creative thinking and the ability to work together in math.

Creative thinking and mathematical collaboration skills of fourth grade students

The data from experiment 1 and experiment 2 will be used to see the differences in the creative thinking abilities of students in mathematics in grade IV of elementary school in Limboro District, Polewali Mandar Regency, using the problem-based learning model assisted by mobile learning media and the discovery learning model assisted by visual media. Experimental group 1 was carried out in grade IV of

elementary school 010 Palece, and experimental group 2 was carried out in grade IV of elementary school 008 Camba-camba. From Table 8 and Table 9, you can see the results of the descriptive analysis of the creative thinking skills of students in Experimental Group 1 and Experimental Group 2.

Table 8. Creative Thinking Ability Data Experiment 1

		Experiment 1 (Posttest)	Experiment 1 (Pretest)
N	Valid	29	29
	Missing	29	29
Mean		89,48	59,86
Std. Error of Mean		1,276	1,430
Median		91,00	59,00
Mode		84[a]	56
Std. Deviation		6,869	7,698
Variance		47,187	59,266
Range		25	28
Minimum		75	44
Maximum		100	72
Sum		2595	1736

Table 9. Creative Thinking Ability Data Experiment 1

		Experiment 2 (Posttest)	Experiment 2 (Pretest)
N	Valid	29	29
	Missing	29	29
Mean		89,48	85,62
Std. Error of Mean		1,276	1,321
Median		91,00	84,00
Mode		84[a]	84
Std. Deviation		6,869	7,113
Variance		47,187	50,601
Range		25	25
Minimum		75	75
Maximum		100	100
Sum		2595	2483

We got information about the creative thinking skills of students in experimental group 1 and experimental group 2 by giving them written tests before and after the experiments. These tests were used to see if there were any differences in the creative thinking skills of fourth-grade elementary school students who were taught using computer-based problem-based learning or visual media-based discovery learning. However, before the hypothesis test was carried out, a prerequisite test was first carried out, including the normality test, homogeneity test, homogeneity test of the variance-covariance matrix/Box M, and multicollinearity test. The following are the results of the prerequisite test.

The Shapiro-Wilk test was conducted using a computer program, specifically the SPSS version 22 program. The results of the average score analysis for the pretest (Experiment 1) showed a Sign value > α of 0.073, and the average score for the posttest

(Experiment 1) displayed a Sign value > α of 0.123. This evidence indicates that there is a difference between the pretest score and the posttest score in experimental group 1, so it is concluded that the data is normally distributed. Furthermore, the results of the analysis of the average score for the pretest (Experiment 2) show a Sign value > α of 0.061, and the average score for the posttest (Experiment 2) shows a Sign value > α of 0.135. This indicates that there is a difference between the pretest score and the posttest score in experimental group 2, so it is concluded that the data is normally distributed.

Furthermore, based on the results of the analysis of the average score for the pretest (Experiment 1 and Experiment 2), it shows a sign value > α of 0.698. This indicates that the pretest (Experiment 1 and Experiment 2) has similar variances, so it is concluded that the data is homogeneous. Meanwhile, the results of the analysis of the average score for the posttest (Experiment 1 and Experiment 2) show a Sign value > α of 0.843. This indicates that the posttest (Experiment 1 and Experiment 2) has similar variances, so it is concluded that the data is homogeneous.

Based on the results of the pretest data analysis in the Test Results, the Box's M value was obtained as 0.055, with a Sig. value of 0.817. We conclude that the variance-covariance matrix for both dependent variables (experiment 1 and experiment 2) is the same. Furthermore, the results of the posttest data analysis (experimental groups 1 and 2) show that in the test results, the box's M value was obtained as 0.034, with a Sig. value of 0.855. We conclude that the variance-covariance matrix for both dependent variables (experiment 1 and experiment 2) is the same. The analysis also got a tolerance value of 1.000, which is higher than 0.1000, as shown in the coefficients output table in the Collinearity Statistics section. While the VIF value is 1.000, it is within the acceptable range. Therefore, we can conclude that the regression model does not exhibit any symptoms of multicollinearity.

Furthermore, to test the differences in creative thinking abilities of experimental class 1 and experimental class 2, a paired-sample t-test was used. The SPSS analysis yielded a Sig value of 0.028. With a p-value of 0.028 where <0.05, because <0.05, then H0 is rejected and Ha is accepted. This indicates that there is a significant difference at a probability of 0.05, so it can be concluded that there is a difference in the creative thinking abilities of fourth-grade elementary school students in mathematics between students taught by the problem-based learning model assisted by mobile learning media and the discovery learning model assisted by visual media. The following are the results of the paired samples test of creative thinking ability presented in Table 10.

Table 10. Results of the Paired Samples Test of Creative Thinking Ability

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Experiment 1 - Experiment 2	3,862	8,947	1,661	,459	7,265	2,325	28	,028

Mathematical collaboration skills of fourth grade elementary school students

The data from experiment 1 and experiment 2 will be used to see the differences in the mathematical collaboration abilities of fourth-grade students of elementary school in Limboro District using the problem-based learning model assisted by mobile learning media and the discovery learning model assisted by visual media. Experimental group 1 was carried out in class IV of elementary school 010 Palece, and experimental group 2 was carried out in class IV of elementary school 008 Camba-camba. The following is the data on the collaboration abilities of students in experimental group 1 and experimental group 2, presented in Tables 11 and 12.

Table 11. Collaboration Ability Data Experiment 1

		Experiment 1 (Final Condition)	Experiment 1 (Initial Conditions)
N	Valid	29	29
	Missing	29	29
Mean		81,28	49,55
Std. Error of Mean		1,571	1,143
Median		87,00	55,00
Mode		87	55
Std. Deviation		8,460	6,156
Variance		71,564	37,899
Range		23	19
Minimum		64	36
Maximum		87	55
Sum		2357	1437

Table 12. Collaboration Ability Data Experiment 2

		Experiment 2 (Final Condition)	Experiment 2 (Initial Conditions)
N	Valid	29	29
	Missing	29	29
Mean		81,28	72,86
Std. Error of Mean		1,571	1,810

	Experiment 2 (Final Condition)	Experiment 2 (Initial Conditions)
Median	87,00	73,00
Mode	87	73
Std. Deviation	8,460	9,749
Variance	71,564	95,052
Range	23	27
Minimum	64	60
Maximum	87	87
Sum	2357	2113

Before the hypothesis test is carried out, prerequisite tests are first carried out, including a normality test, a homogeneity test, a homogeneity test of the variance-covariance matrix/Box M, and a multicollinearity test. The results of the analysis of the average score of collaboration ability meet the requirements and criteria for conducting a hypothesis test.

To test the difference in collaboration ability between experimental class 1 and experimental class 2, a paired-sample t-test was used. The SPSS analysis results yielded a Sig value of 0.001. Since the p-value is 0.001, which is less than the significance level of 0.05, we reject H0 and accept Ha. This statistic indicates that there is a meaningful/significant difference at a probability of 0.05, so it can be concluded that there is a difference in the collaboration ability of grade IV elementary school students in Limboro District, between students who are taught the problem-based learning model assisted by mobile learning media and the discovery learning model assisted by visual media. The following are the results of the T-test of collaboration ability presented in Table 13.

Table 13. Results of the Paired Samples Test of Collaboration Ability

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Experiment 1 - Experiment 2	8,414	11,996	2,228	3,851	12,977	3,777	28	,001

Discussion

The results of the data analysis of students' creative thinking skills before the Problem-Based Learning model was applied showed that there were 29 students out of 29 total students who met the criteria for being creative and quite creative, with an average pretest score of 59.86. Meanwhile, the results of the data analysis of students' collaboration skills before the Problem-Based Learning model was applied showed that

there were 29 students out of 29 total students who met the criteria for being quite collaborative and less collaborative, with an average initial condition score of 49.55.

Furthermore, the results of the data analysis of students' creative thinking skills before the Discovery Learning model was applied showed that there were 29 students out of 29 total students who met the criteria for being creative and quite creative, with an average pretest score of 58.59. Meanwhile, the results of the data analysis of students' collaboration skills before the Discovery Learning model was applied showed that there were 29 students out of 29 total students who met the criteria for being quite collaborative and less collaborative, with an average initial condition score of 48.43. We conclude that the average initial scores of students' creative thinking skills and collaboration skills do not significantly differ.

The data analysis results showed that after applying the problem-based learning model, 29 students met the criteria for being very creative, with an average posttest score of 89.48. Also, when the Problem-Based Learning model was used to look at how well students worked together, the results showed that 29 of them met the criteria for being very collaborative and collaborative, with an average final condition score of 81.

Furthermore, the data analysis results showed that after the Discovery Learning model was applied, 29 students met the criteria for being creative and very creative, with an average posttest score of 85.62. Meanwhile, the data analysis results showed that after applying the Discovery Learning model, 29 students met the criteria for being collaborative and very collaborative, with an average final condition score of 72.86. Based on the discussion, it can be concluded that there is a significant difference in the average score of students' creative thinking skills and collaboration skills after the treatment.

The relationship between group members, who support and help each other and create a pleasant learning atmosphere, was the key to achieving success. Weak students receive input from high-ability students, thus increasing their learning motivation. This motivation has a positive impact on learning outcomes. Students learn more from their friends in group lessons than from teachers. This learning process emphasizes student involvement to actively interact so that they can construct their own knowledge.

The Problem-Based Learning model seeks to activate students to learn by seeking harmonious interactions between students in a pleasant classroom atmosphere (Yusof et al., 2012; Abidin & Sulaiman, 2024). Individual responsibility means that the success of the group depends on the individual learning of all group members. This responsibility focuses on efforts to help others master the material given.

Additionally, it was seen that students in both experimental groups were actively learning using the Problem-Based Learning model and the Discovery Learning model. This meant that they met the active criteria, even though some students were already actively learning. However, the student activity indicators classify student activities as successful or effective if they fall within the good activity range. The analysis of student activity observation data shows that the average percentage of student activity frequency with the Problem-Based Learning and Discovery Learning models is in the good activity range. With the problem-based learning and discovery learning models, the learning

process can be effective because, with the learning tools designed, teachers are no longer the source of as much information as possible for students. The teacher's job is to reveal what students already have, and with their reasoning, they can ask questions appropriately at the right time so that pupils are able to build their knowledge through reasoning based on the initial knowledge possessed by the students.

At a significance level of 5% ($\alpha = 0.05$), the inferential statistical analysis showed that the data from the pre- and post-tests (about the students' creative thinking skills) in experimental groups 1 and 2 followed a normal distribution. The pretest values for experimental groups 1 and 2 were 0.073 and 0.061, respectively, and the posttest values were 0.123 and 0.135, respectively. We also conducted a homogeneity test on the data derived from the homogeneity test. Levene's test for equality variances was used, with a significance level of 5% ($\alpha = 0.05$). The Levene test value before the test in experimental groups 1 and 2 was 0.698, and the Levene test value after the test was 0.843. This finding indicates that the data on the creative thinking ability and collaboration ability of students (pretest and posttest) in experimental groups 1 and 2 are homogeneous at a significance level of 5% ($\alpha = 0.05$).

Furthermore, we conducted a prerequisite test, known as the homogeneity test of the variance-covariance matrix, or Box M, prior to the hypothesis testing. The results of the pretest data analysis showed that both dependent variables had the same variance-covariance matrix (experiment 1 and experiment 2). The box's M value was 0.055, with a sig. value of 0.817. Meanwhile, the results of the posttest data analysis (experimental groups 1 and 2) showed that the Box's M value obtained was 0.034, with a Sig. value of 0.855. Therefore, we can conclude that both the dependent variables (experiment 1 and experiment 2) share the same variance-covariance matrix. We also conducted a multicollinearity test to determine the linearity of the two dependent variables. Based on the statistical test, it indicated that the two dependent variables did not show symptoms of multicollinearity in the regression model. The value obtained is tolerance 1,000 greater than 0.1000. The VIF value falls short of 10,000.

The first research hypothesis test uses MANOVA (Multivariate Analysis of Variance). The test is used to determine the differences in creative thinking and mathematical collaboration abilities of students in experimental group 1 and experimental group 2. Based on the results of the MANOVA analysis, the significant value of creative thinking ability shows 0.040 where <0.05, and the significant value of collaboration ability shows 0.001 where <0.05. Consequently, we reject H0 and accept Ha. Based on this, we can say that students who are taught using the problem-based learning model and visual media are better at creative thinking and working together on math problems than students who are taught using the discovery learning model and visual media.

The second hypothesis test aims to determine whether there is a difference in the creative thinking abilities of students in mathematics in grade IV elementary school with the problem-based learning model assisted by mobile learning media and the discovery learning model assisted by visual media. Based on the results of data analysis with the Paired Sample T-Test statistical test, it shows that the significant value, or p-value, is

0.028. With a p-value of 0.028 where <0.05, because the p-value <0.05, then H0 is rejected and Ha is accepted. This shows that there is a meaningful/significant difference at the probability level of 5% (0.05), so it can be concluded that there is a difference in the creative thinking ability of grade IV elementary school students with the problem-based learning model assisted by mobile learning media and the discovery learning model assisted by visual media.

Furthermore, to test the third hypothesis, namely whether there is a difference in collaboration ability between experimental class 1 and experimental class 2. Based on the results of data analysis with the Paired Sample T-Test statistical test, it shows that the significant value, or p-value, is 0.001. With a p-value of 0.001, which is less than 0.05, H0 is rejected and Ha is accepted. This shows that there is a meaningful/significant difference at the probability level of 5% (0.05), so it can be concluded that there is a difference in the collaboration abilities of grade IV elementary school students with the problem-based learning model assisted by mobile learning media and the discovery learning model assisted by visual media.

4. CONCLUSION

The analysis and discussion of the research results yielded several significant conclusions.re is a significant difference in the ability of creative thinking and mathematical collaboration of fourth-grade elementary school students between students taught by problem-based learning models assisted by mobile learning media and discovery learning models assisted by visual media. Based on the results of the MANOVA analysis, the significant value of creative thinking ability is 0.040, which is smaller than the significance level of 0.05, and the significant value of collaboration ability is 0.001, which is smaller than the significance level of 0.05. Therefore, we conclude that students' abilities in creative thinking and mathematical collaboration differ. Furthermore, there is a difference in the ability to think creatively in mathematics among fourth-grade elementary school students in Limboro District between students taught by problem-based learning models assisted by mobile learning media and discovery learning models assisted by visual media. The Paired-Sample T-Test analysis results demonstrate this, yielding a Sig value of 0.028. The p-value for this analysis is 0.028. So, the significant value is smaller than the significance level of 0.05. Therefore, we conclude that a meaningful/significant difference exists, with a probability of 0.05.

In addition, there is a difference in the ability of fourth-grade elementary school students' mathematical collaboration between students taught by the problem-based learning model assisted by mobile learning media and the discovery learning model assisted by visual media. The Paired-Sample T-Test analysis results demonstrate this, yielding a Sig value of 0.001. The p-value for this analysis is 0.001. So, the significance value is smaller than the significance level of 0.05. Therefore, we conclude that a meaningful/significant difference exists, with a probability of 0.05.

As a suggestion, for teachers, the problem-based learning and discovery models are alternatives that can be used for active learning in other mathematical materials needed in

this era, especially students' creative thinking skills and collaboration skills. Problem-based learning and discovery learning models are also good at getting students to think creatively and work together to solve math problems, according to more research that was done in different schools with different characteristics.

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