The effect of the guided inquiry learning model on the ability to apply digital engineering concepts at Makassar Aviation Polytechnic

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ABSTRACT

This research discusses the importance of implementing humanist parenting patterns and guided inquiry learning models in improving cadet learning outcomes at the Makassar Aviation Polytechnic. A humanist parenting style creates an academic environment that is conducive, democratic, and respects individual uniqueness, to form a professional, ethical, and environmentally conscious character. The guided inquiry model encourages cadets' active and creative participation in the learning process. This method emphasizes independent problem-solving through the scientific process, including problem formulation, hypotheses, analysis, and conclusions. In its application, the teacher provides initial guidance that is gradually reduced so that the cadets can carry out independent inquiry. This research aims to determine the effect of the guided inquiry model on cadets' ability to apply digital engineering concepts. The research results show that the guided inquiry model has a significant impact and is more effective than conventional methods. Cadets who use this model demonstrate increased understanding, skills, and active involvement in the learning process. In addition, research finds that creativity does not have a significant effect on learning outcomes, and learning outcomes are determined more by the application of the guided inquiry model. It is hoped that this research can contribute to improving the quality of vocational education in the aviation sector and become a reference for the development of similar research in the future.

I. Introduction

The guided inquiry learning model plays a role in developing students' critical and analytical thinking skills, making them active subjects in learning [1]. The guided inquiry learning model develops students' critical and analytical thinking skills, making them active subjects in learning [2]. This research aims to determine the influence of the guided inquiry learning model on learning outcomes in digital engineering courses at the Aviation Polytechnic of Makassar and explore the role of creative thinking skills in this process. The results can provide practical recommendations for improving the quality of vocational learning and can become a reference for further study.

A. Theory

1) Guided Inquiry Learning.

Moore [3] states that the roles of teachers and students in inquiry learning can be divided into three as follows: 1) guided inquiry, 2) modified inquiry, and 3) open inquiry [4]. Guided inquiry is a learning model that can train students' skills in carrying out the investigation process by collecting data in the form of facts and then processing these facts so that students can build conclusions independently as answers to questions or problems the teacher gives [5]. From the description above, it can be concluded that the guided inquiry learning model is a learning model in which the teacher guides students to carry out learning activities by asking initial questions and providing direction in a discussion.

2) Guided Inquiry Learning Syntax.

The following section presents a detailed description of the roles and activities undertaken by both teachers and students within each phase of the Guided Inquiry Learning Model. This structured syntax outlines the progressive steps in which educators facilitate the learning process initially providing direction and scaffolding, then gradually transferring responsibility to students as they engage in problem identification, data analysis, and knowledge construction through inquiry-based tasks.

Table 1. Guided Inquiry Learning Syntax

Syntax	Teacher Activities	Student Activities
Investigate a phenomenon	Exploring students' initial knowledge by revealing phenomena	Demonstrate initial knowledge related to phenomena in everyday life
…	…	…
Communicate new knowledge	Facilitate discussion of investigation results in class	Communicate the results of the investigation in class and discuss them

3) Experimental Learning

The experimental learning model is an approach to the learning process where students are involved in experimental activities or trials to understand certain concepts. This approach emphasises students' direct and interactive experiences with learning materials, allowing them to observe, collect data, and draw conclusions [6].

a) Experimental Learning Syntax

Table 2. Experimental Learning Syntax

No	Steps/Stages	Description
1	Determining Learning Goals	Determine the independent variable, dependent variable, and control variable. Design experimental procedures clearly, including instructions for students.
…	…	…
7	Reflection and Further Learning	Invite students to reflect on their experiences. Discuss the implications of the experimental results and their relationship to the broader context.

II. Method

A. Research Design

This research uses a quantitative approach with a quasi-experimental design. In quantitative research, variables are described numerically and analysed using inferential statistics. This research is considered a quasi-experiment because it is impossible to strictly control all variables that might influence the treatment and results (learning outcomes), as in a pure laboratory experiment. Subjects are grouped randomly, and existing classes cannot be changed because they must follow a predetermined curriculum.

This research design uses a 2 x 2 factorial design, which allows researchers to manipulate two variables simultaneously to observe their interaction effects. The primary focus of research is to assess the impact of independent variables, both independently and simultaneously. This design allows researchers to analyse the two variables' main effects and interactions between treatments. The research subjects were Aviation was used as treatment. The moderator variable in this research is the level of creative thinking, which is used to see how creativity influences learning outcomes in applying the learning model presented in Table 3.

Table 3. Concept and Measurement of Research Variables

Research Variables	Measurement
Learning outcomes	Student learning outcomes are measured at the level of remembering concepts, applying concepts and using procedures classified from Merrill's learning taxonomy.
Level of Creative Thinking	4 (four) indicators of creative thinking according to Torrance: original, flexibility smoothness elaboration in high and low levels
Learning model	Guided Inquiry Experiment

B. Research Procedures

1) Experiment Preparation Stage

The research was conducted in early January 2024 by conducting a preliminary study, namely compiling research instruments and discussions with lecturers in the Digital Engineering course. In this research, the initial stage is preparing the instruments for collecting data and conducting experiments. The instruments used in this research are as follows: (1) a creative thinking level test instrument, (2) a set of tests to test the learning outcomes of Digital Engineering material, (3) Semester Learning Plan (RPS), (4) Practicum Event Unit (SAP), (5) Cadet worksheets in the experimental model, (6) Learning modules along with cadet worksheets in the guided inquiry model.

2) Experimental Implementation Stage

The implementation of the experiment begins by giving a creative thinking level test, which is planned to be carried out from April 9, 2024, to April 12, 2024. Students are given a creative thinking level test instrument to identify each research subject's creative thinking level. Students are given lessons using the learning plans that have been provided. The guided inquiry learning design was given to the experimental class and the control group. The learning process for digital engineering courses is carried out over two meetings, with a time allocation of 200 minutes for each meeting. Table 4 shows the order of basic competencies, topics, primary material, and time allocation.

Table 4. Sequence of Basic Competencies, Topics, Main Material, and Time Allocation

Basic Competencies	No	Topik	Main Order	Time
Basic competencies Describe the forms of sequential logic circuits and design sequential logic circuits	1	RS and D Flip-flop	Definition of flip-flop like a flip-flop Design and working of RS flip-flop and D Flip-flop	4X50”
	2	JK Flip-flop	Characteristics, design and working of JK Flip-flop	4X50”
	3	Register	Definition of register kind of register how to work and characteristics of bipolar integrated circuit Shift register	4X50”

3) Post-Experimental Stage

After the experimental research activities, which involved providing treatment on applying the guided inquiry learning model during two meetings, both groups were given an essay test for the Digital Engineering

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course. The final test aims to determine the influence of the treatment in the experimental group and the control group on Digital Engineering learning outcomes, the impact of the level of creative thinking on learning outcomes, and the interaction effect of implementing the guided inquiry learning model and the level of creative thinking on the learning outcomes of Digital Engineering courses.

C. Research Subjects

This study involved cadets from the Aviation Polytechnic of Makassar, specifically those enrolled in Level III, Semester 6 of the Air Navigation Technology Study Program. The participants were drawn from three academic cohorts: Batches XIIA, XIIB, and XIIC, representing a targeted sample with relevant exposure to digital engineering coursework.

The previous section stated that conditions did not allow for the random determination of research subjects. Therefore, this research used a purposive sampling technique, namely a sampling technique based on the researcher's initial knowledge of the population and the specific objectives of the study. Based on this technique, sample determination is based on researchers' assumptions and knowledge about the population to determine a particular representative sample.

1) Place and Time of Research

This research was carried out at the Aviation Polytechnic of Makassar and the Aviation Polytechnic of Surabaya from January 10, 2024, to August 30, 2024.

D. Data Collection Technique and Research Instruments

1) Data collection technique

The data collection in this study employed a direct approach, utilizing multiple techniques to ensure comprehensive and accurate data acquisition. Specifically, learning outcomes were assessed through structured testing instruments, wherein students were presented with verbal and descriptive questions designed to evaluate their ability to apply digital engineering concepts. These assessments were aligned with Merrill's Learning Theory, focusing on the cognitive processes of remembering, applying, and executing procedures relevant to the instructional objectives.

In this research, an essay test is used to determine learning outcomes. Researchers carried out two assessments, namely a pre-test and a post-test. The pre-test was used to determine the similarities between the research subjects, namely the experimental and control classes. The final test (post-test) was carried out to determine the learning process/treatment results. The post-test was given to the experimental group and the control group. The instruments used in this research consisted of: (a) Test of creative thinking level, (b) Test of learning outcomes, (c) Validation sheet for learning tools, (d) Observation sheet for Cadet activities, (e) Observation sheet for implementation of learning plans presented in Table 5.

Table 5. Research Instruments

Objective	**Rated aspect**	**Instrument**	**Observed data**	**Respondent**	**Time**
Knowing the level of creative thinking	uniqueness/originality, fluency, flexibility and elaboration/elaboration	*Test Torrence Creative Thingking (TTCT)*	TTCT Test Results	Learners	Beginning of research penelitian
...	...	...	...	...	...
Validate the guided inquiry practicum instructions	Guided Inquiry Syntax	Guided Inquiry practicum instructions validation sheet	Guided Inquiry Cadet Activity Sheet (LKT).	Material and learning design expert	Beginning of learning.

E. Instrument test

1) Instrument test

This study employed two forms of internal validity to ensure the accuracy and credibility of the research instruments: content validity and construct validity. Content validity was established through expert evaluation of the learning tools and assessment instruments, ensuring alignment with the intended learning objectives. Meanwhile, construct validity was assessed specifically for the learning outcomes instrument, aiming to verify that the test items accurately measured the theoretical constructs related to students' ability to apply digital engineering concepts.

Learning Tools: The validity of the learning tools in this research was carried out using the Semester Learning Plan (RPS), Lecture Reference Unit (SAP), and Cadet Activity Sheet (LKT) / Digital Engineering LKT. Learning tools are validated using content or expert validity.

Learning Outcomes Test: Construct validity testing was carried out on 20 people. Learning outcome test items are carried out by correlating the question item scores and the total construct score. Product-moment correlation is used to test the correlation between item and total scores. The item score is the X value, and the total score is the Y value. Whether an item is significant or not significant can be seen by comparing the calculated R-value with the r table for the degree of freedom (df) = n-k in this study, namely 20-2 or df = 18, at a significance level of 0.05; the r table is 0.444. The product moment (rxy) calculation results are compared with Table 1 (rxy) with a significance level of 5%. If the calculated r is positive and greater than the table r, then the question item is said to be valid.

Reliability Test: In this research, the reliability test was carried out using the Alpha coefficient with the SPSS 22 application.

F. Data Analysis Techniques

1) Prerequisite Test

a) Normality Test

The normality test determines whether the sample data comes from a normally distributed population. Some normality test techniques include the chi-square test, Lilliefors, Q-Q Plot, and Kolmogorov-Smirnov. This research uses the Kolmogorov-Smirnov and Shapiro-Wilk tests with the help of SPSS 22 software. The results are compared using a Q-Q plot to clarify whether the data is normally distributed or close to normal. Data is normal if the points on the Q-Q Plot are spread around the diagonal line and follow its direction. Normality and homogeneity criteria are based on a significance level of 5% with a confidence level of 95%.

b) Homogeneity Test

To find out whether the variance of the scores measured in the two samples has the same variance or not, a homogeneity test is carried out. Populations with variances that are the same size are called populations with homogeneous variances, while populations with variances that are not the same size are called populations with heterogeneous variances. In this research, the homogeneity test uses the SPSS 22 application. In the prerequisite test, the data is said to be homogeneous if the P-value,â• 0.05.

c) Hypothesis Testing

Data was analyzed on learning outcome tests between the control and experimental classes after using the guided inquiry learning model. This research used a 2-way ANOVA to look for interactions between the learning model, level of creative thinking, and learning outcomes. Comparative research analysis with sources of diversity is not due to one factor (treatment). In contrast, other factors are sources of diversity (with two or more samples) using two-way ANOVA.

III. Results and Discussion

A. Result Data

The following description of the research data represents three variables: the guided inquiry learning model and the experimental learning model as the independent variable, the level of creative thinking as the moderator variable, and the learning outcomes of the ability to apply concepts as the dependent variable. Data from the innovative thinking level test results for the experimental and control groups are presented in Table 6.

Table 6. Result Level of Creative Thinking

Experimental Class				**Control Class**			
Class A		***Class B***		***Class A***		***Class B***	
No	Level of Creative Thinking	No	Level of Creative Thinking	No	Level of Creative Thinking	No	Level of Creative Thinking
1	High (1)	1	Low (2)	1	High (1)	1	Low (2)
…	…	…	…	…	…	…	…
24	Hight (1)	24	High (1)	24	Low (2)	24	High (1)
		25	Low (2)	25	High (1)	25	Low (2)
		26	High (1)				

The Guided Inquiry Class consists of classes A and B with 50 cadets from the DIII Air Navigation Engineering (TNU) program at Poltekbang Makassar and Poltekbang Surabaya. This experimental class consisted of 24 cadets with a high level of creative thinking and 26 with a low level of thinking. In detail, class A has 14 highly creative cadets and 10 low-creative cadets, while class B consists of 10 highly creative cadets and 16 low-creative cadets.

The control group consisted of 50 cadets from classes C and D. In this group, 28 cadets had a high level of creative thinking, and 22 had a low level of thinking. In detail, class C has 16 highly creative cadets and nine lowly creative cadets, while class D includes 12 highly creative cadets and 13 lowly creative cadets. Table 7 shows that learning outcomes using the guided inquiry learning model in the DIII Air Navigation Engineering Study Program are available.

Table 7. Result of Experimental Class

No	**Experimental Class**				
	Class A		**No**	**Class B**	
	Pretest Skor	***Posttest Skor***		***Pretest Skor***	***Postest Skor***
1	76	84	1	76	74
…	…	…	…	…	…
			26	74	84
Result of PreTest			Result of Post-test		
Highest Skor		85	Highest Skor		92
Lowest Skor		55	Lowest Skor		67
Average Skor		70,48	Average Skor		80,22

Table 8 presents data on learning outcomes using the experimental/control class learning model in Class C and D. Based on Table 8, there is an increase in the average learning outcomes of cadets in the Digital Engineering course from pre-test to post-test, both in the experimental and control groups. In the experimental class (guided inquiry learning model), students with a high level of creative thinking (24 people) got the highest score of 94 and the lowest of 62, with an average of 80.96. Meanwhile, students with a low level of creative thinking (26 people) had the highest score of 92 and the lowest of 67, with an average of 79.54. Overall, the experimental class of 50 students had a mean of 80.22 and a standard deviation 7.04.

Table 8. Result of Control Class

Control Class					
No	Class A		No	Class B	
	Pretest Skor	***Posttest Skor***		***Pretest Skor***	***Postest Skor***
1	67	76	1	61	80
…	…	…	…	…	…
25	68	86	25	67	67
Result of PreTest			Result of Post-test		
Highest Skor		84	Highest Skor		94
Lowest Skor		48	Lowest Skor		53
Average Skor		66,62	Average Skor		74,9

In the control class (experimental learning model), students with a high level of creative thinking (28 people) achieved the highest score of 94 and the lowest 58, with an average of 78.21. Meanwhile, students with a low level of creative thinking (22 people) got the highest score of 92 and the lowest of 58, with an average of 74.59. Fifty students in the control class had an average of 76.62 and a standard deviation of 8.28. Overall, of the 100 students involved in this research, highly creative students (52 people) had an average of 79.48, and low creative students (48 people) had an average of 77.27, with an overall average of 78.42 and a standard deviation of 7.86.7,86.

B. Data Analysis

In the Lillefors Significance Correction test from Kolmogorov-Smirnov and Shapiro-Wilk, Table 9 presents the learning outcomes data on the ability to apply concepts using the SPSS version 29 program to the guided inquiry learning model and the experimental learning model.

Table 9. Tests of Normality

Tests of Normality						
	Model	***Kolmogorov-Smirnov***[a]			***Shapiro-Wilk***	
		Statistic	***df***	***Sig.***	***Statistic***	***df***
Result	Inquiry Model	.118	50	.081	.954	50
	Experiment	.098	50	.200*	.981	50

Tests of Normality		
	Model	Shapiro-Wilk[a] Sig.
Result	Inquiry Model	.050
	Experiment	.576

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

The results of the Lillefors Significance Correction test from Kolmogorov-Smirnov and Shapiro-Wilk show: (1) through the Kolmogorov-Smirnov test, conclusions were obtained for the learning outcomes of the guided inquiry learning model and the experimental learning model, the significance level was above 0.05 (0.081 and 0.200 greater than 0.05), then the conclusion is obtained that the distribution of the two learning outcomes data is normal, (2) through the Shapiro-Wilk test, the conclusion is obtained for both the learning outcomes of the guided inquiry learning model and the experimental learning model, the level of significance or probability is above 0.05 (0.050 and 0.576 is greater than 0.05), so it can be concluded that the distribution of the two learning outcomes data is normal.

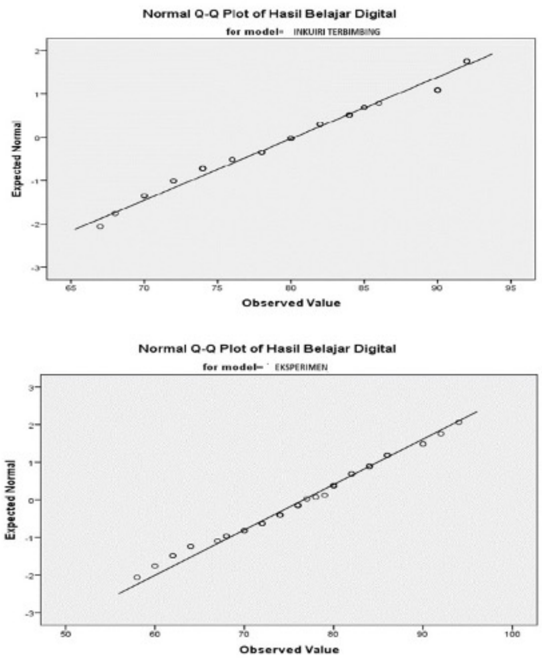

Fig. 1. Normal Q-Q Plot Experimental Learning

Based on Figure 1, the normal Q-Q Plot for learning outcomes from the guided inquiry learning model or experimental learning model shows that the data points are spread around the diagonal line, the distribution of the data points is in the same direction as the diagonal line, and no data is far away from the distribution. This means that the data for all groups can be said to be normally distributed.

Hypothesis testing is carried out on digital learning result data after cadets learn using the guided inquiry and experimental learning models by paying attention to the level of creative thinking and the influence of interactions. The proposed hypothesis will be tested using the analysis of variance (ANOVA) test. The proposed hypothesis is whether the guided inquiry learning model influences learning outcomes in the ability to apply Digital Engineering concepts. Data analysis was carried out on the learning outcomes test of the ability to apply Digital Engineering concepts between the control class and the experimental class after using the guided inquiry learning model, which is presented in the following table:

Table 10. Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	510.908[a]	3	170.303	2.919	.038
…	…	…	…	…	…
Corrected Total	6112.360	99			

There are differences in learning outcomes in the ability to apply digital engineering concepts between class groups using guided inquiry and experimental strategies.

The class group that uses the guided inquiry model has a minimum score of 67 and a maximum of 92, with a class average of 80.22. Meanwhile, the class group with the experimental model has a minimum score of 58 and a maximum of 94, with a class average of 76.62. Furthermore, the level of significance of the influence of the guided inquiry learning model on the learning outcomes of Makassar Aviation Polytechnic cadets can be seen in the Test of Between-Subjects Effects.

Based on Table 4.8, the model is significant. A count of 0.014 < 0.05, so it can be concluded that H0 is rejected. The conclusion is that the guided inquiry learning model influences the learning outcomes of the ability to apply digital engineering concepts for Makassar Aviation Polytechnic cadets.

The effect of variance between the learning model and learning outcomes based on Type III Sum of Squares is:

$$\frac{366{,}781}{621082} \times 100\% = 5{,}90\%$$

Cadet learning outcomes are only influenced by 5.90% and other factors affect the rest.

C. Discussion

The discussion will be directed at the influence of guided inquiry and experimental learning models, the level of creative thinking as an independent variable on learning outcomes, and the ability to apply digital engineering concepts as the dependent variable [7]. The results of hypothesis testing will be discussed based on the results of the 2x2 factorial analysis of variance, namely the main effect and the effect of interactions between the variables in the research.

Research shows that using the guided inquiry learning model significantly influences learning outcomes, especially in the ability to apply digital engineering concepts [8]. The average score for the experimental class that used the guided inquiry model reached 80.96, higher than the control class that used conventional methods, namely 78.21. This indicates that the guided inquiry model effectively increases the understanding and application of digital engineering concepts [9]. These findings can be a consideration for lecturers to use the guided inquiry learning model, especially in learning material that requires critical and analytical thinking, such as sequential logic [10].

Various studies support the effectiveness of the guided inquiry model in improving learning outcomes and critical thinking skills in multiple fields, including science and engineering (Isfahani, 2020).

The guided inquiry model improves conceptual understanding and is essential in developing scientific process skills and metacognitive awareness—students who. Students who learn with this method show higher engagement and obtain better academic grades than students who learn with traditional teaching methods [11].

However, research suggests that this model may not always significantly improve all aspects, such as science process skills, so further adjustments and development are needed. Thus, the guided inquiry model offers great potential to support active and meaningful learning, but its effectiveness must be continuously evaluated for optimal implementation (Altia, 2024).

IV. Conclusion

Based on data analysis, the guided inquiry learning model is proven to significantly affect learning outcomes in applying digital engineering concepts. The learning outcomes of cadets who use this model are better than those in the control class. The guided inquiry model encourages active learning by exploring the learning environment, increasing student activity, understanding, and engagement. This approach fosters critical thinking, scientific literacy, and the ability to analyse and understand scientific information. In addition, this method gives students the freedom to explore new ideas and work in groups, which contributes to improved understanding of concepts and overall learning outcomes.

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