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STUDY THE EFFECTIVENESS OF HEURISTIC STRATEGY WITH METACOGNITIVE AND INVESTIGATION APPROACH TO THE STUDENTS MATHEMATICAL PROBLEM SOLVING ABILITY

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ABSTRACT:

The aim of this study is to analyze the effectiveness of heuristic strategies of each class of learning approach, creativity, and their interactions with the students' mathematical problem-solving skills in the sequence and series material. This study is a quasi-experimental study with a 2 x 3 factorial design. The stratified cluster random sampling technique was used here in this study for the sample collection. The instruments used to collect the data were a mathematics preliminary ability test, a creativity questionnaire, and a mathematics problem-solving ability test. Based on the results of hypothesis testing using a two-way variance analysis with unequal cells and further testing, it is concluded that: (1) The Students who are taught with the Metacognitive learning approach have better mathematical problem-solving skills than the students who are taught with the Investigative learning approach. (2) The Students with a higher level of creativity have better problem-solving skills than the students with the level of lower creativity. (3) The Students with the high level of creativity taught with the metacognitive approach have better problem-solving skills than the students with the level of moderate or low creativity taught with the Investigative learning approach, and the students with moderate creativity have better problem-solving skills than students with low creativity. (4) In the high level of creativity category, students who are taught learning with the metacognitive approach have better mathematical problem-solving skills than the investigative learning approach. In the category of medium and low levels of creativity, students who use the metacognitive learning approach have the same mathematical problem-solving skills as students who are given learning with the investigative learning approach.

1 Introduction

Education is a mindful struggle to produce a learning atmosphere and the learning procedure so that participants can actively develop their potential to have a religious divine asset, self-control, behavior, aptitude, noble character,

and the skills needed by themselves and society [1,2]. The sharpness of global competition in various aspects of human life demands that each member of society can adapt himself to all changes that occur. The main component that plays a major role in this competition is the quality of human resources. Along with the development of knowledge and technology, this is directly proportional to the rapid changes in life. This means that humans need self-sufficiency, both from the mindset, behavior, and adequate skills to adapt to these changes. Of course, we are required to be able to improve the quality of ourselves by having skills, the ability to solve problems (problem solver) so that we can overcome and develop the problems or challenges that arise from the rapid change. One strategy to improve the quality of human resources is to position the education sector as the main tool in development. Mathematics is one of the basic sciences that studies an important role in various aspects of life, because mathematics is a universal science that causes the growth of the latest technology, has an important role in the various disciplines, and also develops human thinking [3]. Mathematics is an efficient tool and is needed by all sciences, and without the help of mathematics, everything will not get meaningful progress [4]. Thus, mathematics plays a role in the ongoing development of science and world civilization. Therefore, in the context of implementing mathematics teaching, it is necessary to make plans or preparations so that the learning process can be more effective, efficient, and directed. Effective in the process and in the achievement of learning outcomes, efficient in the use of time and energy, and focused on achieving the objectives that have been applied. However, the reality on the ground is not yet what was expected. Low mathematics learning outcomes can be caused by the teacher's ability to apply inappropriate learning methods or strategies, for example, the learning process which tends to be teacher-centered while students are more likely to be passive. As result, the students cannot be able to develop their mathematical thinking skills. For example, teachers still use mechanical teaching methods, rarely give problems that are not routine, and emphasize more on drill [5]. Realizing the importance of a learning approach for developing the mathematical problem-solving skills of students, it is necessary to have a mathematics learning environment that involves more students actively in the learning process. This can be possible by developing an alternative form of learning that can reflect the active involvement of students in responding to knowledge.

Mathematics education as part of the educational process, in general, is faced with a major task, namely preparing the students to become reliable problem-solvers in dealing with mathematical problems in life. Therefore, the authors make problem-solving ability with heuristic strategies as one of the focuses studied in this study [6].

The ground reality emphasis that the learning process in schools is too much emphasized on the doing aspect but less on the thinking aspect [7]. What is being taught in the class is more related to manipulative skills problems or how to do something but less about why this is so and what the implications are. In other words, the basis of understanding in learning is only memorization, not reasoning, problem-solving, or the ability to think as a basis for understanding. As a result, the development of students' mathematical reasoning and problem-solving skills is hampered [8]. Therefore, problem-solving learning is very close to the teacher because problem-solving is an important activity related to everyday life. Problem-solving will provide several new experiences to students in understanding mathematics material and other fields of study globally [9]. Sequences and series are also some of the most important materials in mathematics which are used in our everyday life and many problems can be solved by using the rules of the r series [10]. For example, the calculation of bank interest, the calculation of increase in production, and the profit of a business. To

solve this problem, you can use solutions such as solving the sequence and series material. Learning mathematics with a heuristic strategy in mathematics learning that focuses on learning activities, helps, and guides students if they encounter difficulties, and helps develop problem-solving skills [11,12]. Learning mathematics using a heuristic strategy is systematic learning, which makes cognitive conflict as a starting point for the learning process which is resolved by self-regulation of each student so that the student builds his knowledge through experience and interactions with the environment, meaning how the teacher helps and directs students to think and be able to solve problems interactively [13]. Heuristics is a step of thinking and an effort to find and solve a mathematical problem or problem. In this way, this mathematics develops and then is applied to solve practical problems. [14]. Metacognitive is a term derived from the adjective metacognition. Some other terms that refer to metacognition are metamemory and Meta componential skills and processes [15]. Metacognition has two basic words namely Meta and cognition. Meta means after or exceeding and cognition means skills related to the thought process. Furthermore one can define that metacognition is the process of thinking about thinking, knowledge about knowledge, or reflection about actions [16]. Mathematical investigation activities have several characteristics like finding the pattern, self-discovery, reducing the teacher's role, using one's method, being exposed, limited to the teacher's experience not being in control, divergent, and many more [17]. A factor that is still often neglected in various mathematics education studies is student learning creativity, including achievement creativity in learning mathematics [18,19,20,21]. Along with the development of the world of communication, television stations are competing to attract the attention of the public, with interesting programs broadcast during student hours at home. Some students cannot respond wisely to this phenomenon, they become less enthusiastic in learning, on the contrary, more enthusiastic about watching television. Therefore, there needs to be an effort to increase students' learning creativity, especially achievement creativity in learning mathematics. Responding to this, it is important to do this as an effort to reveal comprehensive information about the symptoms that appear in learning practices related to student achievement creativity in learning mathematics.

2 Methodology

2.1 Data Collection

This research was conducted in Nawabshah city District Shaheed Benazir Abad in the year 2018-19. The population of this study was all students in Nawabshah. Sampling was carried out using a stratified cluster random sampling technique so that the research sample was selected as follows:

1) Students of GBDC with class XI-Pre-Engineering (Block-A) as the first experimental class and XII-Pre-Engineering (Block-B) as the second experimental class.

2) Students of GGDC with class XI-Pre-Engineering (Block-A) as the first experimental class and class XI-Pre-Engineering (Block-A) as the second experimental class.

3) Students at SACHAL SARMAST Degree College XI-Pre-Engineering (Block-A) as the first experimental class and SACHAL SARMAST Degree College XI-Pre-Engineering (Block-B) as the second experimental class. Research data collection methods include documentation, tests, and questionnaires. The documentation method was used to know the students' initial problem-solving ability. The test method is used to obtain data on students' problem-solving skills. The questionnaire method was used to obtain data on student creativity.

2.2 Data Analysis

Before conducting the experiment, a balance test was carried out on the initial mathematical ability using a t-test. Data on mathematical problem-solving skills were analyzed by using two-way variance analysis with unequal cells. Previously, prerequisite tests were carried out on the initial ability data and mathematical problem-solving abilities the Lilliefors method was used for the population normality test and the Bartlett method was used for the homogeneity test. Furthermore, the multiple comparison test by using Scheffé's method is used if the H_0 is rejected. With $\alpha = 0.05$, it can be concluded that the sample comes from a population that is normally distributed and has a homogeneous variance. The balance test using the t-test concluded that the two experimental classes had a balanced initial ability.

3 Results

Initial Mathematics Ability Data and Balance Test

The following is a description of the data on the initial mathematical skills of students in experimental class one and experiment class two.

Table 1. Description of Students' Mathematical Initial Ability Data.

Group	n	Central Tendency			Data Variability			
		Mean	Mode	Median	Min	Max	R	s
Metacognitive	88	67.01	60	67	33	100	67	12.8
Investigation	98	67.72	70	69	20	90	70	10.8

The results of the prerequisite test concluded that the samples came from populations that were normally distributed and had homogeneous variances. The results of the balance test using the t-test on the data of students' initial mathematical skills obtained the conclusion that the population has a balanced initial mathematical ability.

Research Data and Analysis of Three-Way Variance with Unequal Cells

The data used in hypothesis testing is the mathematics problem-solving ability of students on the subject matter of sequences and series.

Table 2. Description of data of Students' Mathematical Problem-solving Ability.

Learning Approaches	Creativity level	N	Central Tendency			Data Variability			
			Mean	Mode	Median	Min	Max	R	S
Metacognitive	High	29	52.06	48	50	46	60	14	4.35
	Medium	29	43.93	44	44	34	50	16	3.79
	Low	30	38.66	40	39	30	46	16	3.91
Investigation	High	32	48.32	52	50	40	54	14	4.06
	Medium	34	42.29	38	42	38	48	10	3.68
	Low	32	38.68	36	38	32	48	16	4.47

The prerequisite test results concluded that the samples came from populations that were normally distributed and had homogeneous variants. The following shows the results of a two-way variant analysis with different cells.

Table 3. The results for Two-Way Variance Analysis with Unequal Cells.

Source	*Df*	SSQ	MS	F_{obs}	F_{α}	Decision Test

Learning Approach (A)	1	148.035	148.035	9.05	3.95	H_{0A} rejected
Student Creativity (B)	2	4163.176	2081.588	125.58	3.95	H_{0B} rejected
Interaction (AB)	2	108.682	54.341	3.27	3.95	H_{0AB} rejected
Error	180	2961.20	16.45	-	-	-
Total	185	7355.2				

4 Description of the Results of Two-Way Variance Analysis with Unequal Cells

The description of the results of the two-way variance analysis with unequal cells and the mean comparison test is as follows:

4.1 First Hypothesis

Learning mathematics with a metacognitive approach can provide better mathematical problem-solving skills than learning with the investigation approach.

4.2 Second Hypothesis

The differences in mathematical problem-solving skills between students with high, medium, and low learning creativity levels:

1) $F_{\text{High-Medium}} = 93.634 > F_{critical} = 7.60$ so that $F_{obs} \in Df$ which means H_0 is rejected.

The students with a level of high creativity have better mathematical problem-solving skills than students with a level of moderate creativity.

2) $F_{\text{High-Low}} = 243.755 > F_{critical} = 7.60$ so that $F_{obs} \in Df$ which means H_0 is rejected.

The students with a level of high creativity have better mathematical problem-solving skills than students with a level of low creativity.

3) $F_{\text{Medium-Low}} = 36.274 > F_{critical} = 7.60$, so that $F_{obs} \in Df$ which means H_0 is rejected.

The students with a level of moderate creativity have better mathematical problem-solving skills than students with a level of low creativity.

4.3 Third Hypothesis

There is an interaction between the learning approach factor and the student's creativity factor on the mathematical problem-solving ability of the sequence and series material.

4.3.1 From the comparison test between cells using the Scheffee method in learning with the metacognitive approach, the following results are obtained:

a) $F_{11\text{-}12} = 58{,}258 > F_{critical} = 11.01$, then $F_{11\text{-}12} \in Df$ so that H_0 is rejected

In the experimental class that is subjected to learning with a metacognitive approach, the students with a level of high creativity have better mathematical problem-solving skills than the students with a level of moderate creativity.

b) $F_{11\text{-}13} = 160{,}947 > F_{critical} = 11.01$, then $F_{11\text{-}13} \in Df$ so that H_0 is rejected

In the experimental class that is subjected to learning with a metacognitive approach, the students with a level of high creativity have better mathematical problem-solving skills than the students with a level of low creativity.

c) $F_{12\text{-}13} = 24{,}894 > F_{critical} = 11.01$, then $F_{12\text{-}13} \in Df$ so that H_0 is rejected.

In the experimental class that is subjected to learning with the metacognitive approach, the students with a level of moderate creativity have better mathematical problem-solving skills than the students with a level of low creativity.

4.3.2 From the comparison test between cells using the Scheffee method on learning with the investigative approach, the following results are obtained:

a) $F_{21\text{-}22} = 36{,}435 > F_{critical} = 11.01$, then $F_{21\text{-}22} \in Df$ so that H_0 is rejected

In the experimental class that is subjected to learning with the Investigative approach, the students with a level of high creativity have better mathematical problem-solving skills than the students with a level of moderate creativity.

b) $F_{21\text{-}23} = 90.381 > F_{critical} = 11.01$, then $F_{21\text{-}23} \in Df$ so that H_0 is rejected

In the experimental class that is subjected to learning with the Investigative approach, the students with a level of high creativity have better Mathematics problem-solving skills than the students with a level of low creativity.

c) $F_{22\text{-}23} = 13{,}059 > F_{critical} = 11.01$, then $F_{22\text{-}23} \in Df$ so that H_0 is rejected.

In the experimental class that is subjected to learning with the investigative approach, the students with a level of moderate creativity have better mathematical problem-solving skills than the students with a level of low creativity.

4.4 Fourth Hypothesis

From the results of the comparison test between cells mean at the level of creativity with the Scheffee method, the following results are obtained:

1) $F_{11\text{-}21} = 12.935 > F_{critical} = 11.01$, then $F_{11\text{-}21} \in Df$ so that H_0 is rejected.

In the high creativity category, students who were given learning with the metacognitive approach had better mathematical problem-solving skills than students who were taught with the investigative approach.

2) $F_{12\text{-}22} = 2.559 < F_{critical} = 11.01$, then $F_{12\text{-}22} \in Df$ so that H_0 is accepted.

In the medium creativity category, students who are given learning with the metacognitive approach have the same mathematical problem-solving skills as students who were taught with the investigative approach.

3) $F_{13\text{-}23} = 0.0004 < F_{critical} = 11.01$, then $F_{13\text{-}23} \in Df$ so that H_0 is accepted.

In the low creativity category, students who are given learning with the Metacognitive approach have the same mathematical problem-solving skills as students who were taught with the investigative approach.

5 Conclusion

Based on the data analysis by two-way variance with unequal cells, the following conclusion can be made:

A. The metacognitive learning approach to the heuristic strategy results in better problem-solving skills than the Investigative learning approach.

B. The students with a level of high creativity have better problem-solving skills than the students with a level of medium or low creativity, and the students with a level of moderate creativity have problem-solving skills than students with a level of low creativity.

C. In students who are given metacognitive and investigative learning, students with a level of high creativity have better problem-solving skills than students with a level of moderate or low creativity, and students with a level of moderate creativity have better problem-solving skills than students with the level of low creativity.

D. In the high level of creativity category, students who are given learning with the metacognitive approach have better mathematical problem-solving skills than the students who are given learning with the investigative approach. Whereas in the category of medium and low creativity levels, students who were given learning with the metacognitive approach had the same mathematical problem-solving skills as the students which were given the learning with an investigative approach.

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