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IMPROVING GIFTED STUDENTS' MATHEMATICAL COMPUTATIONAL THINKING ABILITIES THROUGH THE INQUIRY TRAINING MODEL. IS IT EFFECTIVE?

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Abstract

This study aims to analyse the mathematical computational thinking (CT) skills of gifted students before, during, and after being given the Inquiry Training (ITM) learning model. The research was conducted at Islamic school for the 2020/2021 academic year online involving two gifted students. The research method used is single-subject research with an A-B-A design. Data collection using mathematical CT ability test instruments accompanied by assessment rubrics and interviews. Analysis of research data was carried out by percentage techniques and visual analysis. The results of this study show that: (1). The use of ITM learning models can effectively improve the mathematical CT skills of gifted students; (2). Before being given the ITM model, the mathematical CT ability of gifted 1 students was included in the good category and the CT ability of gifted 2 students was included in the sufficient category. During the ITM learning model, the mathematical CT ability of gifted 1 students has increased but is still included in the good category and the CT ability of gifted 2 students has increased from the sufficient category to the good category. After being given the ITM learning model, both gifted students improved so that they were included in the excellent category.

Keywords: Gifted students, Inquiry training model, Mathematical computational thinking skills, Single subject research.

1. Introduction

Computational thinking (CT) ability is a person's ability to think to solve problems [1-3]. This process includes problem formulation, data analysis organization, data representation through abstraction, identifying and automating solutions through algorithmic thinking, analysing and implementing possible solutions, and generalizing problem solving [4].

CT is an important competency because, in addition to later students working in fields influenced by computing, they also have to face computing in everyday life [5]. Strategies in CT can be done in students' thinking skills by simplifying complex problems into several procedures that make it easier for students to understand and solve problems using logic gradually and systematically which is not only important in the process of computer programming but also in other fields including mathematics [6]. Some developed countries have begun to introduce CT at the primary and junior secondary school levels [7]. Even CT is proposed as the ability to complement the 4 C's or deserve to be the "fifth C" in 21st Century Skills [8]. This policy was enacted to train students' CT skills from an early age and as a solution to teachers' difficulties in innovating the monotonous learning approach commonly used [9].

CT of students in general is still low, which is limited to the stage of pattern recognition and the procedures applied are less coherent because abstraction skills and algorithmic thinking have not been carried out in solving mathematical problems [10]. The ability to think computationally mathematically must also be possessed by students who fall into the category of special intelligence and special gifted students because these students play an important role in the progress of a nation. However, there are still many of these students whose achievements are still hidden because they do not get treatment for the talents they have [11].

Children who identify as gifted have a greater chance of success than their peers who are not identified as gifted [12-14]. Mathematics learning conducted by teachers tends to be monotonous and looks more at students' abilities in general, without distinguishing and specializing in the abilities possessed by students [15-19].

Therefore, applied learning narrows the space for students to develop students' mathematical CT skills. Students still have difficulty in formulating problems into mathematical models and performing mathematical procedures in solving contextual problems. This has been reported in many papers [20-25]. One alternative learning model that can be used is the ITM learning model (Inquiry Training Model). According to [26] the use of the ITM model is an effort to help students develop analytical thinking skills, and problem-solving skills, improve intellectual abilities in general, and provide equal opportunities to all students, both students who have low, medium, and high abilities to succeed. Not only cognitive abilities can be developed, but also psychomotor abilities [27]. Therefore, the objectives of this study are (1). Identify the mathematical computational ability of gifted students before, during, and after being taught using the ITM learning model; (2). Analyze the effectiveness of the ITM learning model on the mathematical CT skills of gifted students.

2. Theory

2.1. Inquiry training model

The ITM model was developed by J. Richard Suchman to teach students about a process for investigating and explaining unusual phenomena [28]. Inquiry learning emphasizes the development of cognitive, affective, and psychomotor aspects in a balanced manner and follows students who have above-average abilities [29]. The ITM model keeps students active, develops logical thinking, tolerance and ambiguity, and perseverance, and promotes inquiry and discovery strategies, values, and attitudes necessary to question, think, and improve process skills such as observing, collecting, and organizing data [30]. The learning stages of the ITM model used in this study adopted from [31] (Table 1).

Table 1. ITM model learning stages.

No	Learning Stage	Explanation
1	Encounter with the problem	At this stage, the teacher will give problems to students. The teacher will also explain the inquiry process by giving questions that will be answered with "yes" or "no" answers. At this stage, students will also conduct an inquiry process by providing questions that will be answered with "yes" or "no" answers according to the context of the problem
2	Data gathering-verification	At this stage, students will write down information known from the problem. From the information obtained from the problem, students will make a selection of the information they have written so that relevant information is obtained to solve the problem
3	Data gathering-experimentation	At this stage, students develop information that has been selected from the previous stage. Students conduct a more detailed exploration of information relevant to the problem. The teacher directs students to be able to develop information relevant to the problem
4	Formulating an explanation	At this stage, students write down the data on the problem in the form of a mathematical model and write down mathematical concepts relevant to the problem to explain the relationship between the problem and mathematical concepts.
5	Analysis of the inquiry process	At this stage, students analyse the entire solving process carried out in determining the solution to the problem. In addition, students also analyse the accuracy of the concepts used with data taken from the problem. Students conclude the inquiry process used to solve problems and can use the inquiry process on other problems that have similar concepts. The teacher guides students to be able to carry out each stage of student inquiry in formulating questions, formulating problem-solving, determining solutions to problems, and concluding the inquiry process so that they can use mathematical concepts to solve other problems that have similar concepts

2.2. Mathematical CT skills

The ability to think computationally is the ability to approach solving problems, design systems, and understand human behavior based on a fundamental concept in computer science [32]. The ability to think computationally mathematically is the ability to think that involves formulating problems, designing systems, making steps in algorithmic problem solving, and providing conclusions on solving solved problems. CT in mathematics and science taxonomies is divided into four main categories, namely data practices, modeling and simulation practices, computational problem-solving practices, and systems thinking practices [33]. The indicators of mathematical CT ability are modified by [1] as follows: (1). Formulation is to formulate things that are known from the problem; (2). Representation, which is representing data in the form of a mathematical model; (3). Algorithmic, namely making algorithmic instructions in solving problems; (4). Automation, namely automating the settlement model through algorithmic thinking logically and systematically; (5). Generalization is making conclusions from the process of solving mathematical problems.

3. Method

This experimental research uses a single-subject research method with a reversal design A-B-A consisting of 3 stages, namely the baseline stage (A1), intervention (B), and baseline (A2). The research subjects used in this study were two grade XI students from MA Annajah Jakarta who were included in the category of gifted students in the 2020/2021 school year which were categorized based on IQ scores. Gifted 1 (G1) students aged 16 with an IQ score of 135 (Moderately gifted) and Gifted 2 (G2) students with an IQ score of 112 (Basically gifted). This study consists of three conditions, namely baseline condition 1 (A1), intervention condition (B), and baseline condition 2 (A2). This study used 10 sessions consisting of 3 sessions for baseline condition 1, 4 sessions for intervention conditions, and 3 sessions for baseline condition 2. The data used in this study were the percentage of mathematical CT ability test scores on row and series material as well as algebraic limit functions given to both gifted students in each session.

4. Results and Discussion

The results of the mathematical CT ability test in baseline condition 1 show that subjects G1 and G2 have an average percentage score of 70% (good) and 65% (fair) respectively. Overall, in the intervention condition, there was an increase in the mathematical CT ability score of subject G1 and subject G2 compared to the baseline 1 (A1) condition. In the baseline 2 conditions, subjects G1 and G2 had an average percentage score of 98.33% (very good) and 91.66% (very good), respectively. This shows that the average score obtained by subjects G1 and G2 in baseline 2 is higher than the intervention condition (B). Visually, the percentage score of the mathematical CT ability of subjects G1 and G2 is presented in the following Fig. 1, the mathematical CT ability of subjects G1 and G2 has the highest average at baseline condition 2 (A2). The average mathematical CT ability of G1 and G2 subjects in the intervention condition was higher than in baseline condition 1 (A1) and lower than in baseline condition 2 (A2).

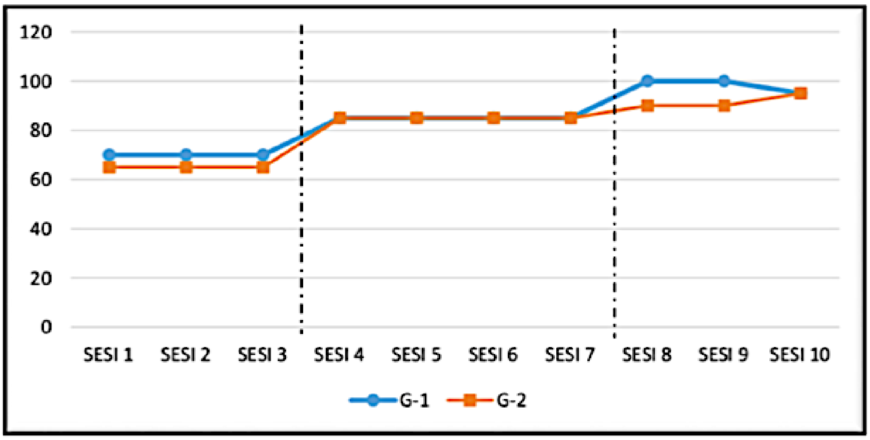

Fig. 1. Percentage of overall data conditions (A-B-A) of subject G1 and subject G2.

4.1. Analysis under conditions

Summary of the results of visual analysis in conditions of mathematical CT skills in each research subject in the following Table 2.

Table 2. Results of visual analysis in conditions of computational mathematical thinking ability of subject G1 and subject G2.

	Condition	Condition Length	Directional Tendency	Stability Tendency	Data Footprint	Stability Level and Range	Level Changes
Subject G1	Baseline 1 (A_1)	3	—	100%	—	70%-70%	0
	Intervention (B)	4	—	100%	—	85%-85%	0
	Baseline 2 (A_2)	3	\	100%	/	100%-95%	+5%
Subject G2	Baseline 1 (A_1)	3	—	100%	—	65%-65%	0
	Intervention (B)	4	—	100%	—	85%-85%	0
	Baseline 2 (A_2)	3	/	100%	/	90%-95%	-5%

4.2. Inter-condition analysis

The main components in the inter-condition analysis include the number of variables changed, changes in their tendencies and effects, changes in stability, changes in levels, and overlapping data. A summary of the results of the analysis of the conditions of mathematical CT skills of each research subject is in Table 3.

Table 3. Results of analysis between conditions of CT skills as G1 and subject G2.

Comparison of Conditions	Subject G1		Subject G2	
	B/A_1 (2:1)	A_2/B (3:2)	B/A_1 (2:1)	A_2/B (3:2)
Number of Variables	1	1	1	1
Changes in Directional Tendencies and Their Effects	— — (=) (=)	— \ (=) (−)	— — (=) (=)	— / (=) (+)
Changes in Stability Trends	Stable to Stable	Stable to Stable	Stable to Stable	Stable to Stable
Data Level Changes	85% - 70% = 15% (+)	95% - 85% = 10% (+)	85% - 65% = 20% (+)	95% - 85% = 10% (+)
Overlapping Data	0%	0%	0%	0%

As a supporter of analysis in conditions and between conditions in this study, a description analysis was carried out based on the opinion of [20] that the effectiveness of an intervention in a single-subject research method can be seen from the difference between two conditions side by side. An intervention is said to be effective if there is a discrepancy between baseline conditions and the intervention. G1 subjects experienced an increase in average value under each condition. In baseline condition 1 (A1) got an average score of 70% with a good category, in intervention condition (B) got an average score of 85% with a good category, in baseline condition 2 (A2) got an average score of 98% with a very good category.

Likewise, G2 subjects experienced an increase in average values under each condition. In baseline condition 1 (A1) got an average score of 65% with sufficient score category, in intervention condition (B) got an average score of 85% with good category, and in baseline condition 2 (A2) got an average score of 91% with very good score category.

The findings of this study as a whole show that in each indicator, G1 subjects get the most scores from formulation, algorithmic, and generalization indicator questions, while G2 subjects from formulation, representation, and algorithmic indicator questions. Findings on subject G1 indicate that gifted students can utilize information and can use information and skills in concluding [34]. In addition, gifted students are inseparable from their thinking style, one of which is reliable in explaining work results sequentially [35]. Findings in G2 subjects In addition to being able to utilize information as in G1 subjects, G2 students also have strong representation skills [36]. This study is important and can give new insight in the current literature regarding how to teach mathematics, as reported in elsewhere [37-38].

5. Conclusion

The results of this study concluded that: (1). The provision of an effective ITM learning model can improve the mathematical CT skills of gifted students; (2). Before being given the ITM learning model, the mathematical CT ability of gifted

1 students was included in the good category and the CT ability of gifted 2 students was included in the sufficient category. During the ITM learning model, the mathematical CT ability of gifted 1 students has increased but is still included in the good category and the CT ability of gifted 2 students has increased from the sufficient category to the good category. After being given the ITM learning model, both gifted students improved so that they were included in the very good category. The recommendations of this study are (1). The application of the ITM model can be used as an option in conducting mathematics learning activities to improve the mathematical CT skills of gifted students; (2). Further research related to the application of the ITM learning model, is recommended to conduct research at different school levels, different subjects, and other thinking skills that are different from this study.

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