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THE EFFECT OF REALISTIC MATHEMATICS EDUCATION LEARNING MODEL ON STUDENTS' TRIARCHIC INTELLIGENCE

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ABSTRACT

This study aims to analyze the effect of the Realistic Mathematics Education (RME) learning model on students' triarchic intelligence. This study is a quasi-experiment with a pretest-posttest control design. The instruments used in this study were: (1) validation sheets; and (2) students' triarchic intelligence tests. The results of this study are: (1) the students' triarchic intelligence scores taught with the RME learning model are in the high category; (2) there is a significant difference on the students' triarchic intelligence scores taught by the RME learning model and direct learning; (3) the students' triarchic intelligence scores taught by the RME learning model is higer than the students' triarchic intelligence scores taught by direct learning; and (4) the implementation of the RME learning model can increase students' triarchic intelligence.

A. INTRODUCTION

Learning in schools based on the Indonesian curriculum (curriculum 2013) is intended to prepare students to live as individuals who are faithful and productive, creative and innovative, and able to contribute to the life of society, nation, and state. According to the Program for International Student Assessment (PISA), students must master the following mathematical processes when learning mathematics: mathematically formulating situations; using facts, concepts, procedures, and mathematical reasoning; and interpreting, applying, and evaluating results (OECD, 2016:13–14). Trends In International Mathematics And Science Study (TIMSS), in which it is explained that the mathematical cognitive domain that students must have consists of three aspects, namely: 1) knowing, which includes facts, concepts, and procedures that students must know; 2) applying, which focuses on students' ability to apply knowledge and conceptual understanding to solve problems or answer questions; and 3) reasoning, which is used for non-routine problems, unfamiliar situations, and problems with many stages (Mullis and Martin, 2013:24). Five process standards for learning mathematics are established by the National Council of Teachers of Mathematics (NCTM): problem solving, reasoning, communication, representation, and connection (Carpenter and Gorg, 2000:7).

Sternberg proposed the theory of multiple intelligences (hereafter referred to as "triarchic intelligence"), which includes analytical, creative, and practical intelligence(s) that are consistent with a mathematical thinking (Steinberg, 1997: 314; Farsani et al., 2016). According to Sternberg, analytical intelligence involves the ability to examine, assess, criticize, compare, and contrast information. Creative intelligence consists of the capacities to create, explore, discover, invent, imagine, and predict. Practical intelligence comprises the capacity to apply, use, implement, and apply in practical tasks (Sternberg, 1999; Momani & Gharaibeh, 2017). In this study, analytical intelligence encompasses the capacities to analyze, criticize, compare, and contrast. Creative intelligence encompasses the capacities to create, investigate, discover, invent, and predict. Practical intelligence includes the capacity to apply mathematical concepts and principles to issues in the real world, in other fields, and in mathematics itself.

The link between triarchic intelligence and the mathematical abilities that students must have globally (PISA, TIMSS, and NCTM) indicates the importance of incorporating triarchic intelligence into mathematics education in Indonesia. The purpose of the preliminary research conducted at one of the junior high schools in

Medan, by testing them with a triarchic intelligence test based on each indicator, is to determine each student's triarchic intelligence and consider it into the learning process. The data collected after administering the initial triarchic intelligence exam to students reveals that the mean classical triarchic intelligence score of students is extremely low, equal to 39.29. (the maximum score of 100). Depending on how the exam is administered, it is possible to determine which part of triarchic intelligence is most apparent in each student. In addition, there are students with varying triarchic intelligence scores (high, medium, and low) who have the same triarchic intelligence aspects. Generally, group learning (cooperative learning) organizes students in each study group according to their ability level (high, medium, or low). According to the results of the preliminary research done, it is possible that students with high, medium, and low intelligence have the same most dominant aspects of triarchic intelligence. In this study, the grouping of students in each study group was based on their triarchic intelligence, taking gender, race, and ethnicity into account.

It will be difficult or even impossible, to realize the learning objectives in the Indonesian curriculum as well as the requirements for standard processes (cognitive domains) of learning mathematics that students must have globally until the above problems are resolved. Mathematics learning should facilitate students' development, construction, and formation of concepts, meanings, processes, and values (Bishop, 1991). Such learning is "student-oriented," which emphasizes the students' potential. According to Treffers, de Moor, and Feijs, there are three pillars of the process of learning mathematics that contribute to the development of a mathematical thinking: constructive, interactive, and reflective learning (Hasratuddin, 2017). A Realistic Mathematics Education (RME) approach is one learning strategy that is consistent with the three pillars of the learning process.

Alternative to developing a democratic and character education system is the RME learning approach (Hasratuddin, 2017). Such learning transforms students into "learning subjects" who must actively participate in the construction of formal mathematical knowledge, i.e., in the process of discovering facts, concepts, operations, and mathematical principles from real-world sources. Teachers must consider students as more than empty vessels ready to be filled with formal mathematical knowledge. Teachers must construct conducive learning settings for students to achieve formal mathematical knowledge. Students have potential, but that does not ensure they can independently carry out the construction process. The teacher must guide the construction process so that students can rediscover their formal mathematical knowledge. Guiding of the construction process does not entail delivering a series of instructions to students, but rather studying their thought processes so that the teacher may provide them with the appropriate scaffolding for the construction process he is conducting. The RME learning model can be used as an alternative to improve the triarchic intelligence of students. Thus, the objective of this study is to determine the effect of the RME learning model on the triarchic intelligence of students.

B. RESEARCH METHODS

This type of research is quasi-experimental with a pretest-posttest control design. The grouping of research subjects was carried out randomly; the experimental group was given a learning treatment with a realistic mathematics education (RME) learning model ($X1$), and the control group was given the direct learning model ($X2$); before and after treatment, they were given a pretest and a posttest (O).

$$O \quad X_1 \quad O$$
$$O \quad X_2 \quad O$$

The research subjects were class VII students at a junior high school in Medan, which consisted of 46 students in the experimental group and 48 students in the control group. The research instrument used a Triarchic Intelligence Test (TIT) for two basic competencies of learning contents (TIT 1 and TIT 2), each of which consisted of nine word problems. Data analysis was performed using a qualitative descriptive technique and a t-test.

C. RESULT AND DISCUSSION

RESULTS

1. Validity of the Triarchic Intelligence Test

The activity carried out was asking five experts and practitioners to assess the validity of the Triarchic Intelligence Test (TIT), which was developed based on the specified assessment aspects. Each TIT consists of nine word problems. The validation results from experts and practitioners are presented in Table 1.

Preliminary study were also carried out on 49 students of Class VII (the control group) to measure the statistical validity of TIT. Determining the validity of each problem is done using the product moment correlation formula, and the results are presented in table 2. Based on table 2, it is found that the value of r_{xy} > r_{table}, so it is concluded that each question at TIT I and TIT II meets the valid criteria.

Table 1. Validity of TIT

No.	Assessed Aspects	TIT
1.	Content Validity	Valid
2.	Language and Writing	Minimum Understandable

Table 2. Validity Coefficient of The Triarchic Intelligence Test (TIT)

TIT	Problem	r_{xy}	r_{table}
TIT I	1.	0.290	0,281
	2.	0.589	
	3.	0.591	
	4.	0.645	
	5.	0.292	
	6.	0.427	
	7.	0.606	
	8.	0.784	
	9.	0.730	
TIT II	1.	0.411	
	2.	0.354	
	3.	0.456	
	4.	0.704	
	5.	0.532	
	6.	0.707	
	7.	0.680	
	8.	0.524	
	9.	0.686	

Note
TIT I : Triarchic Intelligence Test I
TIT II : Triarchic Intelligence Test II
r_{xy} : The Validity Coefficient of the Test
r_{table} : Product Moment Constant

Table 3 shows the results of calculating the reliability of TIT I and TIT II using the Alpha formula. Based on table 3, it is found that the value α > r_{table}, so it can be concluded that TIT I and TIT II have a high degree of reliability.

Table 3. Reliability Coefficient of The Triarchic Intelligence Test (TIT)

TIT	Problem	S_i^2	S_t^2	α	r_{table}
TIT I	1.	4.312	137.527	0.721	0,281
	2.	4.871			
	3.	3.422			
	4.	2.632			
	5.	3.102			
	6.	3.019			

	7.	8.873		
	8.	7.014		
	9.	12.180		
TIT II	1.	7.574		
	2.	2.629		
	3.	2.832		
	4.	3.682		
	5.	6.481	196.545	0.709
	6.	6.857		
	7.	9.623		
	8.	17.89		
	9.	15.106		

Note
TIT I : Triarchic Intelligence Test I
TIT II : Triarchic Intelligence Test II
S_i^2 : Item Varians
S_t^2 : Total Varians
α : The Reliability Coefficient of the Test
r_{table} : Product Moment Constant

2. Students' Triarchic Intelligence Score

The mean initial and final triarchic intelligence scores of students in the experimental and control groups are presented in Table 4. According to the established criteria, the mean initial triarchic intelligence scores of students in the experimental and control groups are very low and low, respectively.

Table 4. Mean Triarchic Intelligence Scores of Students in Experimental and Control Groups

Groups	Triarchic Intelligence	
	Initial	Final
Experiment	39.29	82.61
Control	43.00	48.26

Based on the results of the normality test conducted (see Table 5), it is concluded that the mean initial score of students' triarchic intelligence in the two groups of research subjects is normally distributed (sig. = 0.184 > 0,05 and sig. = 0.903 > 0,05).

Table 5. Normality Test

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Groups	Stat.	df	Sig.	Stat.	df	Sig.
Initial Triarchic Intelligence	Exp	.120	46	.092	.965	46	.184
	Cont	.73	49	.200*	.988	49	.903

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

Based on the results of the homogeneity test conducted (see table 6), it can be concluded that the average score of students' initial triarchic intelligence in the two groups of research subjects is homogeneous (sig. = 0.259 > 0.05).

Table 6. Homogeneity Test

		Levene Statistic	df1	df2	Sig.
Initial Triarchic Intelligence	Based on Mean	1.292	1	93	.259
	Based on Median	.898	1	93	.346

	Based on Median and with adjusted df	.898	1	91.596	.346
	Based on trimmed mean	1.337	1	93	.250

A t-test is performed based on the results of the normality and homogeneity tests to determine whether there is a difference in the final triarchic intelligence scores of students in the experimental and control groups.

Table 7. Independent Samples Test

		t-test for Equality of Means		
		t	Df	Sig. (2-tailed)
Final Triarchic Intelligence	Equal variances assumed	11.104	93	.000
	Equal variances not assumed	11.323	70.907	.000

Based on the results of the t-tests conducted (see table 7), it can be concluded that there is a significant difference between the final triarchic intelligence scores of students in the experimental and control groups (sig. = 0.000 < 0,05). Based on the mean score of the final triarchic intelligence of the students from the two groups, it can be concluded that the final triarchic intelligence score of the experimental group students who were taught by the RME learning model was better than the triarchic intelligence scores of the control group students who were taught by direct learning.

Increasing the triarchic intelligence scores of experimental group students was classically carried out by determining the average normalized gain value. The average normalized gain value ($\langle g \rangle$) determined using the formula (Hake, 2008: 498): $\langle g \rangle$=$(\langle \%post \rangle - \langle \%pre \rangle)/(100 - \langle \%pre \rangle)$, and obtained $\langle g \rangle$ = 0.71. When the value of $\langle g \rangle$ = 0.71 is compared to the interval criteria of $\langle g \rangle$, it is concluded that the criteria of the experimental group students' increasing triarchic intelligence score are high.

DISCUSSIONS

This is a quasi-experimental study using a pre- and post-test control design. This study aimed to investigate the effect of the RME learning model on the triarchic intelligence of students. The syntax of the RME learning model consists of five stages: (1) proposing a contextual problem; (2) exploring a contextual problem; (3) reflecting on a contextual problem; (4) classical sharing (formalization and generalization); and (5) implementation of formal mathematical knowledge.

This model's syntax indicates that the implementation of learning is based on constructivism (Ernest, 1991; Glasersfeld, 1995; Bozkurt, 2017), which emphasizes teacher dominance in the learning process. In this RME learning model, the role of the teacher differs from that of direct learning. As opposed to direct learning, based on the components of the principle of reaction and management, the teacher does not act as a source of knowledge that provides students with entire mathematical concepts and principles. The teacher establishes connections between students (discussions in their study groups and classically) and students with their learning environment (individually or in groups using the learning materials employed) (van den Heuvel-Panhuizen, 2003; Hasratuddin, 2017). The teacher does not give students a mechanistic sequence of instructions in the construction of formal mathematical knowledge and provides solutions to contextual problems to be solved, but rather acts as a guide or scaffolding giver (Surya and Syahputra, 2017) so that students can rediscover mathematical concepts and principles or solve given contextual problems. The teacher is responsible for ensuring that the syntax of the RME learning model runs correctly, but this is distinct from the interaction between students and their learning environment, which must occur as naturally as possible. In other words, the teacher permits students to utilize both their potential (triarchic intelligence) and prior learning experiences in the construction process.

With the RME learning model, the role of students begins with exploratory activities (Budinski and Milinkovic, 2017) on contextual problems that they receive individually using student books and are guided by the teacher. This exploration facilitates students' use of their triarchic intelligence, in which students try to:

register information that is known and find its connection with the things that are asked in contextual problems; create models of contextual problems in the form of pictures, tables, or schematics; as well as try out the possibilities related to solving contextual problems. This exploratory activity does not restrict the possibility of students finding solutions to contextual problems. However, as a result of this exploratory activity, as few students as possible identify difficulties in solving contextual problems or constructing formal mathematical knowledge. This exploration contributes to each student that he has found things that he should discuss in his triarchic intelligence group later. The next role of the students is to discuss in their triarchic intelligence groups as well as classically. Different students, based on the more prominent aspects of intelligence they have, will use their abilities to discuss their findings in the previous exploration process (Sternberg, 1999; Farsani and Mumthas, 2014; Farsani et al., 2016). The result of the interaction between students in their respective triarchic intelligence groups is a formal process of solving contextual problems, i.e., a shift from the informal "model of" to the formal "model for" (Ernest, 1991; Gravemeijer, 1994; Presmeg, 2003; van den Heuvel-Panhuizen and Drijvers, 2014). The process of solving contextual problems and discovering new formal mathematical knowledge by each distinct triarchic intelligence group indicates that students have various methods for implementing the formal mathematical knowledge they have learned previously. The teacher's scaffolding for each triarchic intelligence group must be based on each group's respective requirements (thinking or solving process).

This RME learning model makes it easier for students to work together or engage in cooperative learning. Cooperative learning is based on two essential components: group goals and individual accountability (Slavin, 2008, 2014; Laal, et al., 2013; Gillies, 2014). Accordingly, each student in a study group or in the class is an individual who is interdependent on one another (based on different potentials) and requires each student's participation in the learning process. This study presents the concept of triarchic intelligence to highlight these two essential components. The basic consideration for including triarchic intelligence aspects in this RME learning model is that the triarchic intelligence aspects are interactively related to: (1) socio-cultural context; (2) motivation; (3) metacognitive; (4) learning ability; (4) thinking ability; (5) declarative and procedural knowledge; and (6) creativity (Sternberg, 2005; Davidson and Kemp, 2011; Shabnam, 2014). The facts show that the organization of students into study groups is based on: (1) three categories of academic abilities, namely high, medium, and low; (2) gender; (3) race; and (4) ethnicity. The aspect of triarchic intelligence is used in this study as a basis for considering student organization in each study group in terms of academic ability.

The implementation of the RME learning model can increase the triarchic intelligence of students in the experimental group. The results of this study are in line with relevant previous research, which shows that the RME approach can improve students' critical thinking skills and conceptual understanding (Hasratuddin, 2017; Hidayat & Iksan, 2015). Students who exhibit strong critical thinking abilities and conceptual understanding show that learning occurs through conceptual understanding, not memorization. Instead, learning occurs through a series of analytical activities, such as comparing, evaluating, criticizing, or contrasting, which is an indicator of analytical intelligence. Students that possess strong analytical intelligence will also have strong critical thinking abilities and conceptual knowledge. Critical thinking abilities and conceptual knowledge are closely related to the capacity to create, explore, discover, innovate, predict, and apply an idea. For example, students who do not have good critical thinking skills and conceptual understanding certainly cannot understand how to generate good ideas or for what particular ideas they are generated. Thus, good creative and practical intelligence are associated with good critical thinking skills and conceptual understanding.

D. CONCLUSION

Based on the results of the data analysis and discussion in this study, several conclusions are put forward as follows:

1. The classical triarchic intelligence scores of students who are taught with the Realistic Mathematics Education (RME) learning model are in the high category,
2. There is a significant difference in the triarchic intelligence scores of students who are taught by the Realistic Mathematics Education (RME) learning model and direct learning,
3. The triarchic intelligence scores of students who are taught by the Realistic Mathematics Education (RME) learning model are better than the triarchic intelligence scores of students who are taught by direct learning,
4. The implementation of the Realistic Mathematics Education (RME) learning model can increase students' triarchic intelligence.

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