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Fostering of Mathematical Critical Thinking Ability Using ARCS Model and Students' Motivation

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ABSTRACT

Mathematical critical thinking skills in mathematics learning is an ability that needs to be mastered by every student in order to support students in the learning process. The purpose of this study was to analyzing the influence and interaction of the ARCS model and learning motivation on students' mathematical critical thinking skills. This research is a quasi-experimental design using cluster random sampling as a sampling technique. The data collection technique used an essay test to determine MCT and a questionnaire to see motivation. The data analysis technique used the normality test, homogeneity, and two-way ANOVA. The results have shown that there is an effect of the ARCS learning model on students' mathematical critical thinking ability, there is no influence of learning motivation on mathematical critical thinking skills, and there is no interaction between ARCS model learning and motivation towards mathematical critical thinking ability. Therefore, the ARCS model can be solution to fostering of mathematical critical thinking abilities.

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A. INTRODUCTION

In line with the progress and development of science and technology which is increasingly rapid, especially in education (Al-Zahrani, 2015; Hayward et al., 2015; Komarudin et al., 2020), it is not impossible that technology and learning will further develop and become a scientific discipline that can play a role in problems-solving in the teaching and learning (Reddy & Panacharoensawad, 2017; Siagan et al., 2019; Y. F. Surya et al., 2020). In regard for students to be active in learning, the purpose of learning is to be able to develop their potential to have religious-spiritual strength, self-control, personality, intelligence, character, and skills (Fallah et al., 2015; Munifah et al., 2019). Studying mathematics has the goal of forming the characteristics of students in analyzing problems to develop their reasoning skills (Barnhart & van Es, 2015; E. Surya & Syahputra, 2017; Widyatiningtyas et al., 2015; Yuliani & Saragih, 2015), such as the ability to think critically, logically, systematically, can think of ideas orally, pictures, maps, diagrams, graphs and others (Komarudin et al., 2020).

In the 21st century, skills were needed to develop of the achievement. Critical thinking for example. The importance critical thinking is the process of making something original (Dumitru, 2019), regarding exploring the dynamic nature of attentional focusing (Toner & Moran, 2016). Critical thinking is an essential skill that needs to be complemented by a person to compete with the developments and changes in primary-day in the classroom (Alper, 2010;

Ismail et al., 2018; Ku, 2009)(Alpers, 2010; Ku, 2009). Therefore, the need to apply this skill as early as school level and as part of a student's preparation for the future (Hartinah et al., 2019; Marin & Halpern, 2011).

The fact was shown that the ability to think mathematically is low including the ability of critical thinking mathematically (Kurniati et al., 2015), and then the critical thinking ability is low in the logical-mathematics classroom (Seventika et al., 2018). Based on field data, 90.90% of students have difficulty understanding mathematical critical thinking skills. Also, based on interview data with mathematics teachers, students are still less interested in learning mathematics. The monotonous learning atmosphere causes students to feel bored because educators convey mathematical concepts still using conventional methods. The other factor that influence the students' low mathematical critical thinking skills are learning motivation (Cho & Heron, 2015; Holmes & Hwang, 2016; Kurniati et al., 2015). Motivation is an important skill in the teaching process. Motivation to learn is encouragement from within and outside of learners who are learning to make some behaviour changes (Tsay et al., 2018; Zepeda et al., 2020), can encourage students to what extend doing success their achievement (Benner et al., 2016; Kraft et al., 2016; Lemberger et al., 2015), and the value as an outcome (Guo et al., 2015; Knievel et al., 2015; Teo & Milutinovic, 2015).

To tackle the phenomenon of problems in teaching and learning, educators are expected to be able to choose the right learning model to tackle the lack of thinking skills and motivate students in learning mathematics (Firdaus, 2017; Komarudin et al., 2020; S Suherman et al., 2020). The model of Attention, Relevance, Confidence, Satisfaction (ARCS) as the solution in the mathematics teaching process (Li & Moore, 2018). ARCS model can create learning motivation to improve student learning outcomes (LAÇİNBAY & YILMAZ, 2020; Tseng & Walsh Jr, 2016; Ying & Yang, 2013). The ARCS model has a flexible nature so that its implementation it can foster the enthusiasm of students who are less interested in certain subjects. (L.-C. Lee & Hao, 2015). Then it can train students to learn independently, be responsible, and create self-confidence (Huda et al., 2019; S Suherman et al., 2018).

Based on the previous study, there is found the positive effect in regard ARCS model with the flipped classroom approach (Aşıksoy & Özdamlı, 2016), these studies were concerning with the development of ARCS model integrated flipped classroom approach, additionally there is the limitation that the lower numbers of students have a bias towards this method since it is new. Other previous studies indicate that the ARCS model raises the focus student at the classroom and making positive expectation for achievement (Malik, 2014), and this study was distance learning. Furthermore, the last study was revealed that the students' having satisfaction with achievement from ARCS learning (Li & Moore, 2018).

Based on the previous article, this research update looks at the influence of both learning models, namely the ARCS model and the conventional model of students' mathematical critical thinking abilities. A more effective learning model will provide a significant increase in mathematical critical thinking abilities. This research was highlighted that mathematical critical concept with ARCS model viewed by students' motivation. Hence, the purpose of the study determine the effect of the ARCS model viewed by students motivation and the interaction between them.

B. METHODS

This research was Quasi-Experimental Design method. The population was 169 in grade 7 in junior high school in East Lampung. The sampling used by Cluster Random Sampling with a total sample size of 69 students. The respondents were divided into two groups. The first group was the experimental group, namely learning with the ARCS model. The second group was the control group, namely the model used in school.

The data collection technique was to use an essay test to see the mathematical critical thinking ability and a questionnaire to determine the motivation of students. The instrument was constructed by Cronbach's Alpha and reliability test with Levene statistic. The data analysis technique used the normality test using the Liliefors, the homogeneity test using the Bartlett Test, and the hypothesis test using the two-way ANOVA. The hypothesis are the follow

1. H_{0A} : There is no influence of the ARCS learning model on mathematical critical thinking abilities
   H_{1A} : There is an effect of the ARCS learning model on mathematical critical thinking abilities
2. H_{0B} : There is no influence of students' motivation on mathematical critical thinking abilities
   H_{1B} : There is an effect of students' motivation on mathematical critical thinking abilities
3. H_{0C} : There is no interaction between the ARCS model and students' motivation
   H_{1C} : There is an interaction between the ARCS model and students' motivation

The steps of the ARCS are the follow (Pratama et al., 2019)

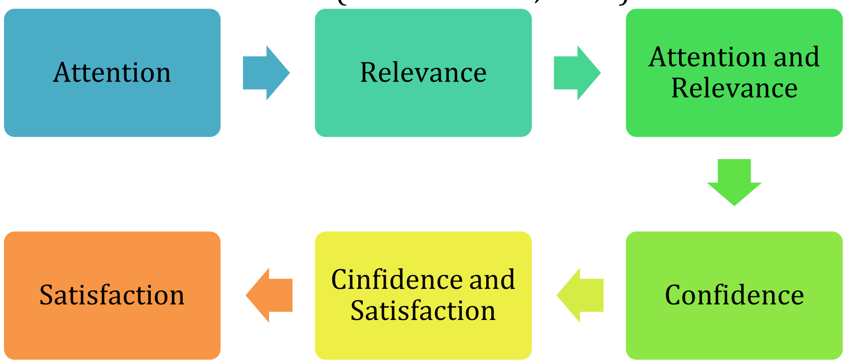

Figure 1. ARCS Steps

Based Figure 1, The teacher reviews the material that students have learned and links the lessons to be discussed. Then in the relevance step, the teacher explains the objectives and benefits of learning and explains the learning material in detail. Furthermore, attention and relevance, the teacher give real examples, and there is a relationship with everyday life. The benefit of providing sample questions is that students find it easier to understand and remember the material. In the confidence step, the teacher guides students in understanding the learning material presented to increase students' confidence in working on the teacher's practice questions. In the confidence and satisfaction track, students are allowed to ask questions, respond to, and work on problems. The last is satisfaction, the teacher provides feedback to stimulate the thinking patterns of students.

The mathematical critical thinking (MCT) was indicated by indicator as follow (H. Lee et al., 2016)

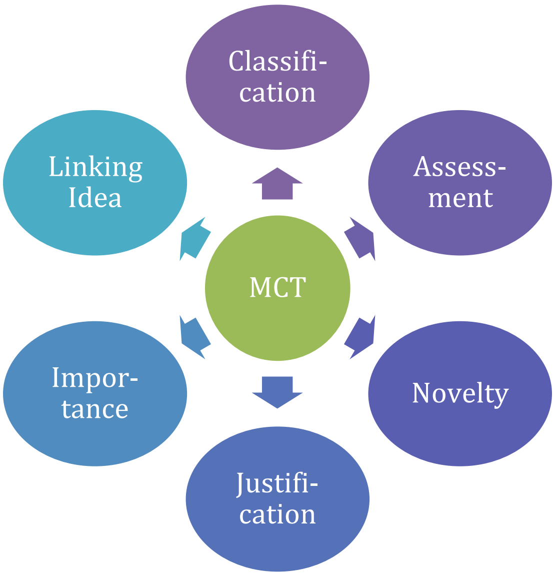

Figure 2. The Indicators of Mathematical Critical Thinking

C. RESULT AND DISCUSSION

The instrument test data analysis was loading by Cronbach's Alpha .408 (p < .05) for the reliability and the validity was highest for each question (p < .05). Additionally, the questionnaire was .607 and (p < .05) for reliability and validity respectively. The analysis data for post-test was loading to found the maximum and minimum in experiment and control class. Furthermore, find the central tendency as follow mean, median, mode, range, and deviation standard as following in Table 1

Table 1. Mathematical Critical Thinking Ability Score

Critical Thinking Ability	Max	Min	Mean	Mode	Median	Range	St. Dev
ARCS Model	100	70.91	83.63	90.91	85.45	29.09	9.19
School Model	90.91	52.73	68.41	60	67.27	38.18	10.68

Table 1 shows data on student teaching and learning outcomes from different learning model on the ability to think critically. In regard table, it can be seen that the ARCS model is more influencing in increasingly students' critical thinking ability. That is to say that the median and mean values of the ARCS model as experiment class and control class were followed by learning in the school followed. Based on the analysis that the ARCS model not only raises critical thinking but also achievement students' (Afdarni, 2018). Another loading based on motivation was reported by this study. The motivation questionnaire has been scored in Table 2.

Table 2. Motivation Students' Score

Critical Thinking Ability	Max	Min	Mean	Mode	Median	Range	St. Dev
ARCS Model	129	86	103.3	89	101	43	12.55
School Model	122	80	102.2	96	101	42	10.50

Based on Table 2, it can be seen that the motivation students' score indifference class is the difference. With the loading rules, it is clear that the mean and deviation standard is the highest scores in the ARCS class then the control class. Concerning the motivation definition that intervention class can support motivation for each student (Jungert et al., 2018). Before reporting the test, it is necessary to construct normality and homogeneity data as a testing hypothesis. The normality testing data are displayed in Table 3 and homogeneity loading data are exploring in Table 4.

Table 3. Normality Test on Mathematical Critical Thinking Abilities and Motivation

Class	Test	Kolmogorov-Smirnov	Sig.	Results
Experiment	MCT Test	.096	$p < .05$	Normal
Control		.132		
Experiment	Questionnaire	.162		Homogeneity
Control		.200		

Based on Table 3, it can be seen that the ARCS model as experiment class and control class is model followed by school was normally distributed.

Table 4. Homogeneity Test on Mathematical Critical Thinking Abilities and Motivation

Aspects	Student Learning Outcomes			
	Levene Statistic	df_1	df_2	sig
MCT	.337	1	69	$p < .05$
Motivation	.253			

In Table 4, we can see that the construct loading data was homogeneity in both aspects of MCT and motivation. The next step were running for the hypothesis. The results data was loading by two-way ANOVA in the table below.

Table 4. The Results of Data Teaching

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4376.266[a]	5	875.253	8.767	.000
Intercept	323090.035	1	323090.035	3236.153	.000
Motivation	279.444	2	139.722	1.399	.254
Model	3491.676	1	3491.676	34.974	.000
Motivation*Model	82.602	2	41.301	.414	.663
Error	6289.775	63	99.838		
Total	408325.891	69			
Corrected Total	10666.040	68			

R Squared = .410 (Adjusted R Squared = .363)
Dependent Variable: Mathematical Critical Thinking

Based on table 4, there is a significant difference between the mathematical critical thinking skills of students in the experimental class and the control class. Thus, the treatment of the experimental class and the control class can be applied to measure the extent of the effect of the increase in mathematical critical thinking skills generated after the treatment. It can be seen that for the learning model the result is $p < .05$, so it can be concluded that there is an influence of the ARCS learning model on students' mathematical critical thinking skills. Furthermore, based on the motivation construct loading that there is no effect between motivation and MCT ($p = .254 > .05$). Additionally, there is no interaction between motivation and ARCS model through MCT ($p = .663 > .05$).

The ARCS Model can make students 'motivation in understanding learning materials (Kurt & Keçik, 2017; Milman & Wessmiller, 2016), prioritizing students' attention and adjusting learning materials so as to foster student self-confidence and change student satisfaction (Ampountolas et al., 2019; Geiger et al., 2017).

The motivational principles compiled in the ARCS learning process consist of Attention, Relevance, Confidence, and Satisfaction. Educators are expected to teach students to be able to grow, improve, and maintain learning motivation. For Students who are motivated to follow the learning process well, the knowledge and thinking power of students will increase (Asfar & Asfar, 2020; Ulandari et al., 2019). Mathematical critical thinking in this research was increasingly by the ARCS model. Regarding the ARCS steps that there are many stages that improving students. These steps can be improving mathematical critical thinking skills by providing basic explanations. This step explains the objectives and benefits of learning in detail. So, it can foster the interest and attention of students. In contrast, there are no steps in the control class. This step is following previous research that can build basic skills in critical thinking (Kurt & Keçik, 2017).

Additionally, the ARCS model can improve mathematical creative thinking ability was because there are steps for confidence and satisfaction. These steps can students' making conclusion about every performance in the class. In other words, feedback by the educator can make students' build self-confidence and report the material in detail. The results were contrast with the previous study that The ARCS model can raise students' motivation (Alhazbi, 2015; Reynolds et al., 2017; Turel & Sanal, 2018). This means that there is a finding that the ARCS model has no effect on student' motivation.

Based on several previous studies, it appears that there are differences in the treatment of the ARCS model with the conventional learning model (Zhang, 2017). This is because the ARCS model can make students more active in the learning process (Keller, 2016), students are trained to be able to solve problems well (Novotná et al., 2014), the knowledge gained by students will take longer to remember, and this learning model is very effective because it is a learning center that prioritizes the role of students and is student-centered. Hence, the ARCS model can be solution to the lack of mathematical critical thinking.

D. CONCLUSION AND SUGGESTIONS

Based on the data analysis and hypothesis testing, the conclusion is: mathematical critical thinking abilities get better with the ARCS model than mathematical critical thinking abilities that use the school model. The student motivation did not influence mathematical critical thinking, and both model and students' motivation not influence mathematical critical thinking. The limitation of this research was focused on grade 7 and the minimum number of samples used. Another thing that there is no feedback in the learning activity and cooperative reciprocity is not controlled, which might be mixed with other exogenous factors (e.g., learning environment and student's previous knowledge), and that is as highlighted researcher in the future.

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