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The Correlation between Metacognitive Skills and Critical Thinking Skills at the Implementation of Four Different Learning Strategies in Animal Physiology Lectures

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Abstract: The empowerment of metacognitive skills has an important role in increasing the capacity of critical thinking and active control of students' cognitive processes in learning. Metacognitive skills can be enhanced through the implementation of learning strategies involving higher-order thinking. The RQA, ADI, RQA integrated with ADI are constructivistic learning strategies that can accommodate these skills. The researches specifically examining the correlation between metacognitive skills and critical thinking skills at the implementation of RQA, ADI, and RQA integrated with ADI learning strategies are still rarely found. This research is a correlational research, aiming at revealing the correlation between metacognitive skills and critical thinking skills. The data of metacognitive skills and critical thinking skills are collected by using a valid and reliable essay test. The samples of this research are the fourth semester (IV) biology education students programming Animal Physiology course in the 2016/2017 academic year consisting of 109 students. The results of this research show that (1) there was a significant correlation between metacognitive skills and critical thinking skills at the implementation of the four learning strategies, (2) the regression equations analyzed using Anova obtain regression lines (not coincide), and non parallel regression lines (intersected); meaning that there is a difference in the increase rate and magnitude of the critical thinking skills influenced by the four learning strategies. It is expected that the teachers and the lecturers always strive to improve the quality of the learning process through the implementation of active and constructive learning strategies.

Keywords: *ADI learning, Animal Physiology, Critical Thinking Skills, Learning Strategy, Metacognitive Skills.*

Introduction

A fundamental aspect of critical thinking is a metacognitive activity that reflects the extent of our own thoughts, so that we can evaluate the results of our thinking and learn from the learning experiences (Vezzosi, 2004). Metacognitive skills are associated with the development of critical thinking and are important aspects in improving the students' cognitive ability (Lockwood, 2003; Warni, Sunyono, Rosidin, 2018). The research conducted by Semerci and Elaldi (2014) showed that there was a significant correlation between all sub-dimensions of metacognitive beliefs and critical thinking values of students. Cakici (2018), Garcia and Pintrich (1992), Gurcay and Ferah (2018), Naimnule and Corebima (2018), all state that there was a positive correlation between metacognitive skills and critical thinking skills. Metacognition is the strongest predictor of critical thinking skills (Ingle, 2007). Metacognition is correlated with critical thinking through the aspect of reflection. This process is in line with Magno (2010), that metacognition factors have a significant correlation with critical thinking. Metacognition leads to higher-order thinking skills that involve active control of certain cognitive processes in learning (Howard, 2004; Imel, 2002; Kozikoglu, 2019; Uzuntiryaki-Kondakci & Capa-Aydin, 2013; Willingham, 2007).

The research conducted by Buku, Corebima, and Rohman (2016) showed that there was a correlation between metacognitive skills and critical thinking skills of class X and XI students with the regression equation of the two variables y = 1.1775x - 0.0295 having a contribution value of 90.80%. These results are consistent with the research conducted by Arslan (2015) who found that there was a positive correlation between metacognitive skills and critical

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thinking skills of students at the University of Sakarya, Turkey. Metacognitive skills have a significant correlation with critical thinking skills (Dwyers, 2014; Halpern, 1993; Hassani & Rahmatkhah, 2014; Lai, 2011). The basis of critical thinking skills is metacognitive skills. Both critical thinking and metacognition are associated with higher-order thinking (Fahim & Dorrimanesh, 2015). The research conducted by Semerci and Elaldi (2014) found that there was a positive correlation between cognitive awareness and critical thinking.

Students need to have metacognitive skills as a key for improve their thinking capacity (Kozikoglu, 2019; Tan, 2004). Metacognitive skills are needed to assist individuals to solve problems (Al-Khayat, 2012; Jousavec, 1994; O 'Neil & Abedi, 1996). Eggen and Kauchak (1990) stated that the empowerment of metacognitive skills in the learning process could help students to be more independent. Metacognition is the key to make learning more meaningful for the students in understanding the meaning of a concept and as a key component of academic success (Alevent, Vincent, & Koedinger, 2002; Dang, Chiang, Brown, McDonald, 2018).

Critical thinking enables the students to process information logically and prepare for independent study. The students who have critical thinking skills can determine which information is important, irrelevant, or useless. Critical thinking brings about clear perception, vision and logical communication methods for explanation (Su, Ricci, & Mnatsakanian, 2016). It can be said that critical thinking plays a decisive role in academic success (Fahim & Ahmadi, 2012) because students can detect the purposes and points of view, assess the reasons for specific content, and make educated decisions based on analytical reasoning. Equipping students with skilled thinking means equipping students with survival skills for the future life (Hasanuddin & Mulyadi, 2012). The students who have critical thinking skills tend to construct knowledge, which is useful for life, so that it can increase their motivation in solving everyday problems (Lai & Viering, 2012).

The thinking skills, including metacognitive skills, in Senior High Schools (Corebima, 2016) and universities in Indonesia (Bahri, Corebima, Amin, & Zubaidah, 2015; Muhlisin, Susilo, Amin, & Rochman, 2016) are categorized as low. The observations results in biology learning conducted by Ariyati (2015) showed that many students were unable to solve problems related to everyday life. The classroom learning has not been able to empower students' metacognitive skills, refering to students practicing their critical thinking skills in problem solving process. The students' ability to solve problems is a part of the indicator of critical thinking skill development (Kim & Choi, 2014; Memduhoglu & Keles, 2016). The conceptual understanding of biology education students related to critical thinking skills is still lacking, the mean score of essay test of critical thinking skills is still an underdeveloped category (Amin, Corebima, Zubaidah, & Mahanal, 2017). Most of biology students have not been able to monitor their own thinking process, so that the results of their examinations are not satisfactory (Saputri, 2017). The empowerment of metacognitive skills is very important so that critical thinking skills also increase. The students who are aware of their metacognitive abilities will be able to improve their learning and academic ability (Perfect & Schwartz, 2004).

Flavell (1976) first introduced the word 'meta-cognition' in the United States. The term 'metacognition' refers to an individual's knowledge of his or her own cognition (Flavell, 1976). Metacognitive skills are the skills which involve self-regulation ability, self-assessment, monitoring and planing, self-assessment of the learning strategies used, and the effectiveness in the problem solving process faced (Kramarski & Mevarech, 2003; Veenman, 2006). Metacognitive skills help students to gain knowledge and to improve their intellectual abilities in the learning process and their learning experiences (Gok 2010; Knox, 2017; Lai 2011). The empowerment of metacognitive skills will increase the students' ability to think about the results of the elaboration of their knowledge in learning (Posthuma, 2015; Fischer, 1998).

Critical thinking is thinking with reasoning and reflection which emphasizes on making a decision about what to believe and what to do (Ennis, 1996). Critical thinking activities will activate the analyzing and evaluating skills, identifying questions, making logical conclusions, and understanding the implications of arguments (Friedrichsen, 2001). The empowerment of students' critical thinking skills in the classroom learning should be continuously done in order that students can have a sense of responsibility for their own learning, help to become active learners, as well as strive to improve their learning experiences and learning identities (Cirik, Colak, & Rich, 2015; Marlowe & Page, 2005; Tuncel & Bahtiyar, 2015).

Lectures should consider empowering the students' metacognitive skills through the implementation of appropriate learning strategies. Metacognitive skill training increases the students' awareness to learn, to plan their learning, to control the learning process, promote critical thinking to evaluate the effectiveness of themselves as students, and to reflect on their learning, as well as to evaluate their own strengths and weaknesses (Bahri & Corebima, 2015). Ideally, the empowerment of critical thinking skills should not be carried out as a separate activity (Amin et al., 2017). There has been a lot of evidence that critical thinking skills can be improved through a variety of learning strategies (Zubaidah, 2010). Educators should try to help students to engage in higher-order thinking through structured assistance (Kuswana, 2013).

There is a significant correlation between metacognitive skills and learning strategies (Yesilyurt, 2013a; Yesilyurt, 2013b). According to Corebima (2009), the implementation of *Reading, Questioning and Answering* (RQA) learning strategy is proven to be able to force students to read the assigned learning materials, so the learning that has been designed can be implemented properly, and the understanding of the learning material can be increased to nearly

100%. Questioning is an important part of conducting inquiry (Hosnan, 2014). By implementing the RQA learning model, the students' metacognition skills can be empowered during the learning process (Amin & Rosmiaty, 2017; Sumampouw, Rengkuan, Siswati, & Corebima, 2016.). The research results showed that the use of RQA strategy can improve critical thinking skills and metacognitive skills (Bahri, 2010; Bahtiar, 2014; Hasanuddin, 2013; Kusuma, 2014; Marthaliakirana, 2014; Prianti, 2014; Zunaidah, 2015).

Argument-Driven Inquiry (ADI) developed by Sampson and Gleim (2009) is an integrated learning unit to encourage students to engage in interdisciplinary work, thereby improving the students' understanding of important and practical concepts in biology. ADI learning strategies help students to develop thinking skills by emphasizing the important role of argumentations in generating and validating scientific knowledge (Sampson, Grooms, & Walker, 2010). ADI learning strategy is not only appropriate to be applied in the laboratory, but also effective in the classroom (Demircioglu & Ucar, 2015; Hidayat, Wahyudin, & Prabawanto, 2018; Sampson, Grooms, Walker, 2010; Sampson & Gleim, 2009). Research results by Hasnunidah (2009), Novianti, Mukti, Yuliskurniawati, Mahanal, Zubaidah (2019), and Roshayanti (2012) show that the use of ADI learning strategy can improve critical thinking skills and metacognitive skills. Although RQA and ADI learning strategies have the potential to develop metacognitive skills and critical thinking skills, further researches related to the strengths of the strategies seen from the contribution value (R2) needs to be conducted.

There have been many pieces of research investigating the correlation of variables in some learning strategies (Amiri & Ahmadi, 2014; Arslan, 2015; Buku, Corebima, Rohman, 2016; Fauziyah, 2013; Hassani & Rahmatkah, 2014; Siswati, 2014). However, to date there has not been any research specifically investigating the correlation between metacognitive skills and critical thinking skills in RQA integrated with ADI, RQA, ADI learning strategies. Therefore, the research on the correlation between metacognitive skills and critical thinking skills at the implementation of RQA integrated with ADI, RQA, ADI learning strategies and conventional learning might show the proper correlation and regression equations primarily especially related to the effectiveness of the regression lines including the contribution. Furthermore, it is important to reveal the differences in the regression equation among the regression equations of the correlation between metacognitive skills and critical thinking skills in the RQA integrated with ADI, RQA, ADI learning strategies as well as conventional learning. After that, it is important to uncover the factors affecting the *slope* and *intercept* coefficients formed from the correlations between metacognitive skills and critical thinking skills in the four learning strategies.

There have not been many researches investigating the correlation between metacognitive skills and critical thinking skills at the implementation of RQA, ADI, and RQA integrated with ADI including in Animal Physiology lecture. Metacognitive skills reflect the extent to which students' strategies can accommodate their knowledge and learning experience through the process of thinking in problem solving. It is essential that students possess these skills in order that they become independent learners and they have the ability to deal with the challenges of the 21st century development. Therefore, it is important to reveal the correlation between the two, and it's regression equation related.

This research aims at revealing the correlation between metacognitive skills and critical thinking skills on the four learning strategies, based on the problems as follows:

1. How is the correlation between metacognitive skills and critical thinking skills at the implementation of the four learning strategies?

2. How is the difference in the regression equations of the correlation between metacognitive skills and critical thinking skills in the four learning strategies?

Methodology

Research Goal

The purpose of this research is to reveal the correlation between metacognitive skills and critical thinking skills in the four learning strategies (RQA integrated with ADI, RQA, ADI learning strategies and conventional learning). This research also aims at revealing the differences in the regression equations related.

Research Design

This research is a quantitative correlational research. This research revealed the correlation between metacognitive skills and critical thinking skills.

Sample

The population of this research was all the students of biology education in Makassar and Maros, South Sulawesi, Indonesia. The samples of this research were the biology education students in the fourth semester programming the animal physiology lecture in the 2016/2017 academic year. The total number of the research subjects was 109 students, randomly selected and distributed to four equal groups based on an equality test. Each group was treated using different learning strategies (RQA, ADI, ADI integrated with RQA, and conventional learning strategies). The four

groups were located at the UIN Alauddin Makassar and STKIP YAPIM Maros, South Sulawesi, Indonesia. This research was conducted from February 2016 to June 2016. The time of the implementation of the research was based on the applied curriculum at UIN Alauddin Makassar and STKIP Yapim Maros, Indonesia. Where the Animal Physiology lecture is programmed in the even semester of 2016/2017.

Data Collection

The research data were the data of metacognitive skills and critical thinking skills in each groups. The procedure of RQA learning strategy is: 1) presenting the topic of the lecture; 2) formulating questions; 3) answering the questions; 4) presenting group assignments. The procedure of ADI learning strategy is: 1) identifying assignments, 2) collecting data, 3) producing tentative arguments, 4) doing interactive argument sessions, 5) preparing written investigation reports, 6) reviewing reports, 7) revising reports, 8) doing reflective discussion. Meanwhile, the procedure of RQA integrated with ADI learning strategy is 1) presenting the topic of the lecture, 2) reading the learning material, 3) preparing questions, 4) identifying assignments, 5) collecting data, 6) producing tentative arguments, 7) presenting group assignments, 8) doing interactive argument sessions, 9) answering questions, 10) preparing written investigation reports, 11) revising reports, and 14) doing reflective discussions.

Before used, the instrument for measuring metacognitive skills and critical thinking skills was intially validated. The instrument was validated by experts and validated empirically. The expert validation included content validity and construct validity carried out by three experts in the field of educational research instruments, biological education, and Animal Physiology. Empirical validation was carried out at 50 sixth semester students of Biology education study program at UIN Alauddin Makassar. The test instrument was also tested for its validity and reliability. The results of the data analysis indicated that the test instrument was valid and reliable.

The metacognitive skills were measured by using a validated essay. A metacognitive skill rubric was used to determine the score of metacognitive skills. It consisted 7 scales (0-7), and it was used as a reference to check the students' answers of each test item. The qualitative categorization of the levels of metacognitive skills referred to Green (2002), namely *super* (85-100), *ok* (68-84), *development* (51-67), *cannot really* (34-50), *risk* (17-33), and *not yet* (0-16). The scores obtained based on the rubric were calculated using the metacognitive skill formula (Corebima, 2009) as the following:

$$\frac{y1+2x}{3} = y2$$

Description:

y1   = the score of concept gaining

y2   = the score of the combination between concept gaining and metacognitive skills

x   = the score of metacognitive skills

The critical thinking skills were measured by using a validated *essay* test. The critical thinking skill scores were obtained by using the scoring rubric of critical thinking skills developed by Zubaidah, Corebima, & Mistianah (2015) adapted from *Illinois Critical Thinking Essay Test* and *Guidelines for Scoring Illinois of Critical Thinking Essay Test* consisting five scales (0-5). The components of the critical thinking skill rubric included: (1) *focus,* (2) *supporting reasons* and *reasoning,*(3) *organization,*(4) *conventions,* (5) *integration.* The critical thinking skill mean were then categorized into two levels, namely *not visible or still underdeveloped* for the mean score range of 1-3, while the mean score range of 4-5 indicated *well developed.*

The data of metacognitive skills and critical thinking skills were collected at the pretest and the posttest.

Analyzing of Data

The data analysis related to the correlation between metacognitive skills and critical thinking skills were analyzed by using regression analysis with a significance level of 0.05. Before analyzed, the data were previously tested by using *One-Sample Kolmogorov-Smirnow* test to determine whether or not the data were normally distributed.

Findings / Results

a. The Correlation between Metacognitive Skills and Critical Thinking Skills at the Implementation of RQA Integrated with ADI Learning Strategy

The regression analysis results of the correlation between metacognitive skills and critical thinking skills in the RQA integrated with ADI learning strategy can be seen in Table 1 to Table 3. The graph of the regression equation related is presented in Figure 1.

Table 1. Summary of Regression Analysis related to the Correlation between Metacognitive Skills and Critical Thinking Skills in the RQA Integrated with ADI Learning Strategy

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.905[a]	.818	.813	2.38713

Table 2. Results of ANOVA Test on the Metacognitive Skills and Critical Thinking Skills in the RQA Integrated with ADI Learning Strategy

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	948.420	1	948.420	166.436	.000[b]
	Residual	210.841	37	5.698		
	Total	1159.261	38			

Table 3. Regression Equation Coefficient Analysis between Metacognitive Skills and Critical Thinking Skills in the RQA Integrated with ADI Learning Strategy

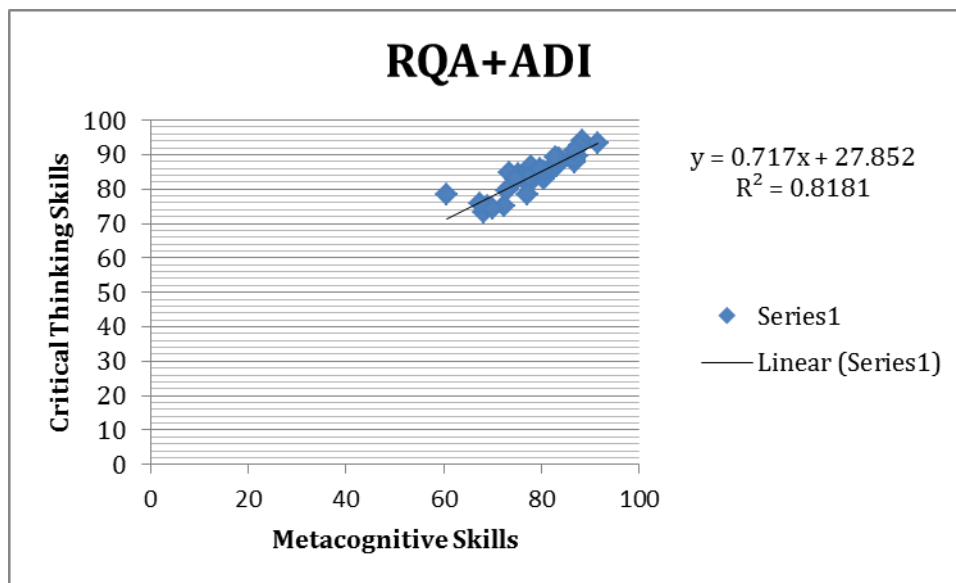| Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	27.852	4.447		6.263	.000
	MetaSkillsComb	.717	.056	.905	12.901	.000

Figure 1. Graph of regression equation between metacognitive skills and critical thinking skills in the RQA integrated with ADI learning strategy

The results of the data analysis in Table 1-3 show that the R value = 0.905, the F value = 166.436 with the significance value of the correlation between metacognitive skills and critical thinking skills of the students as much as 0.00. This means that there is a correlation between metacognitive skills and critical thinking skills at the implementation of RQA integrated with ADI learning strategy; the regression equation obtained is $y = 0.717x + 27 852$ with R^2 value = 0.8181; meaning that metacognitive skills have a contribution of 81.81% towards critical thinking skills, while the remaining 18.19% was the contribution of other factors in addition to metacognitive skills.

b.   The Correlation between Metacognitive Skills and Critical Thinking Skills in the RQA Learning Strategy

The regression analysis results of the correlation between metacognitive skills and critical thinking skills in the RQA learning strategy can be seen in Table 4 to Table 6. The graph of the regression equation related is presented in Figure 2.

Table 4. Summary of Regression Analysis related to the Correlation between Metacognitive Skills and Critical Thinking Skills in the RQA Learning Strategy

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.626[a]	.391	.357	4.02192

Table 5. Results of Anova Test on the Metacognitive Skills and Critical Thinking Skills in the RQA Learning Strategy

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	187.150	1	187.150	11.570	.003[b]
	Residual	291.164	18	16.176		
	Total	478.314	19			

Table 6. Regression Equation Coefficient Analysis between Metacognitive Skills and Critical Thinking Skills in the RQA Learning Strategy

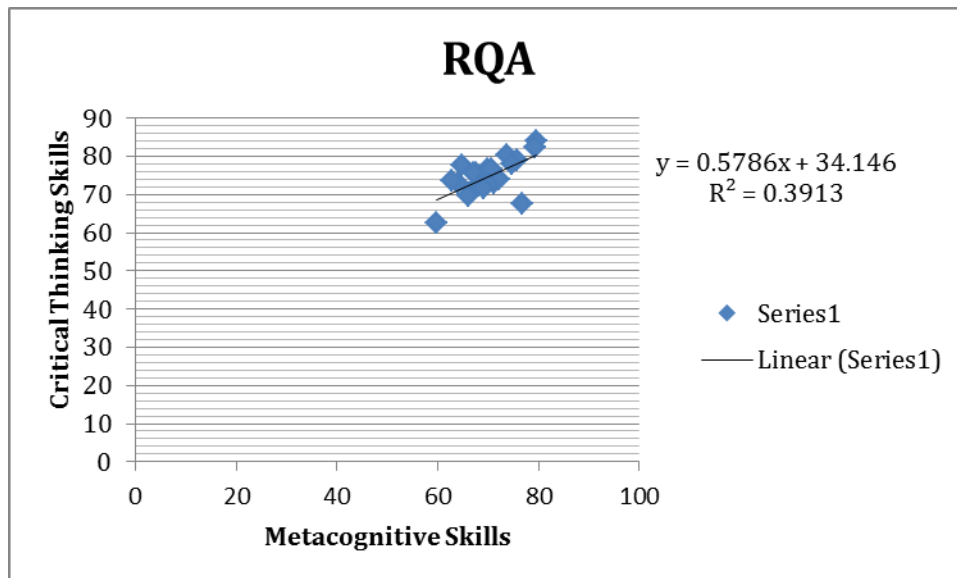| Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	34.146	11.964		2.854	.011
	MetaSkillsRQA	.579	.170	.626	3.401	.003

Figure 2. Graph of the regression equation between metacognitive skills and critical thinking skills in the RQA learning strategy

The results of the data analysis in Table 4-6 show that the R value = 0.626, the F value = 11.570 with the significance value of the correlation between metacognitive skills and critical thinking skills of students as much as 0.03. This means that there is a correlation between metacognitive skills and critical thinking skills at the implementation of RQA learning strategy; the regression equation obtained is y = 0.5786x + 34.146. with the R^2 value = 0.3913; meaning that metacognitive skills have a contribution of 39.13% towards critical thinking skills, while the remaining 60.87% is the contribution of other factors in addition to metacognitive skills.

c. The Correlation between Metacognitive Skills and Critical Thinking Skills in the ADI Learning Strategy

The regression analysis results of the correlation between metacognitive skills and critical thinking skills in the ADI learning strategy can be seen in Table 7 to Table 9. The graph of the regression equation related is presented in Figure 3.

Table 7. Summary of Regression Analysis related to the Correlation between Metacognitive Skills and Critical Thinking Skills in the ADI Learning Strategy

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.949[a]	.900	.897	2.67587

Table 8. Results of Anova Test on Metacognitive Skills and Critical Thinking Skills in the ADI Learning Strategy

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1996.844	1	1996.844	278.877	.000[b]
	Residual	221.969	31	7.160		
	Total	2218.813	32			

Table 9. Regression Equation Coefficient Analysis between Metacognitive Skills and Critical Thinking Skills in the ADI Learning Strategy

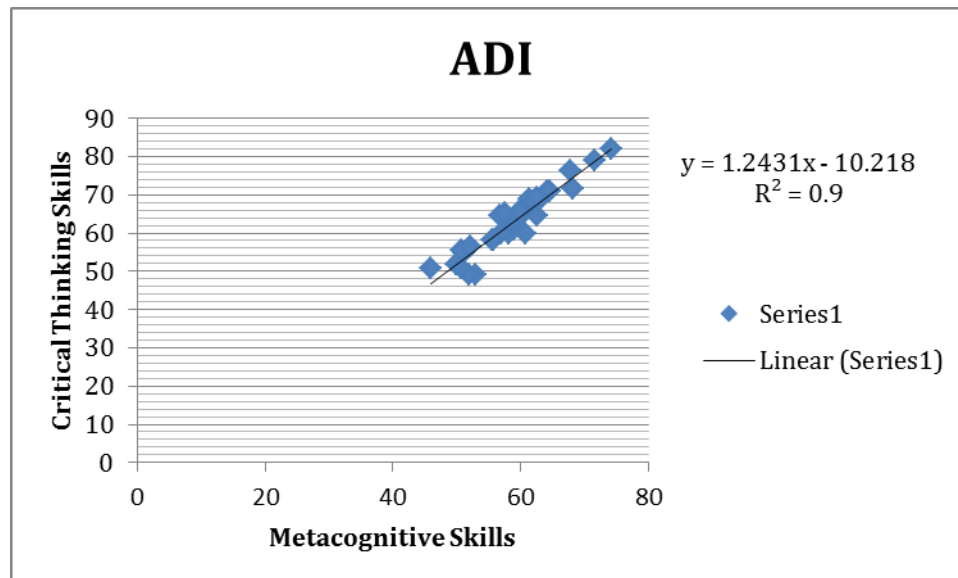| Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-10.218	4.419		-2.312	.028
	MetaSkillsADI	1.243	.074	.949	16.700	.000

Figure 3. Graph of regression equation between metacognitive skills and critical thinking skills in the ADI learning strategy

The results of the data analysis in Table 7-9 show that the R value = 0.949, the F value = 278,877 with the significance value of the correlation between metacognitive skills and critical thinking skills of students as much as 0.00. This means that there is a correlation between metacognitive skills and critical thinking skills at the implementation of ADI learning strategy; the regression equation obtained is y = 1.2431x - 10.218 with the R^2 value = 0.90; meaning that metacognitive skills have a contribution of 90.00% towards critical thinking skills, while the remaining 10.00 % is the contribution of other factors in addition to metacognitive skills.

d. The Correlation between metacognitive Skills and critical Thinking Skills in the conventional Learning Strategy

The regression analysis results of the correlation between metacognitive skills and critical thinking skills in the conventional learning can be seen in Table 10 to Table 12. The graph of the regression equation related is presented in Figure 4.

Table 10. Summary of Regression Analysis related to the Correlation between Metacognitive Skills and Critical Thinking Skills in the Conventional Learning

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.828[a]	.686	.667	2.59799

Table 11. The Results of Anova Test on Metacognitive Skills and Critical Thinking Skills in the Conventional Learning

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	236.209	1	236.209	34.996	.000[b]
	Residual	107.993	16	6.750		
	Total	344.201	17			

Table 12. Regression Equation Coefficient Analysis between Metacognitive Skills and Critical Thinking Skills in the Conventional Learning

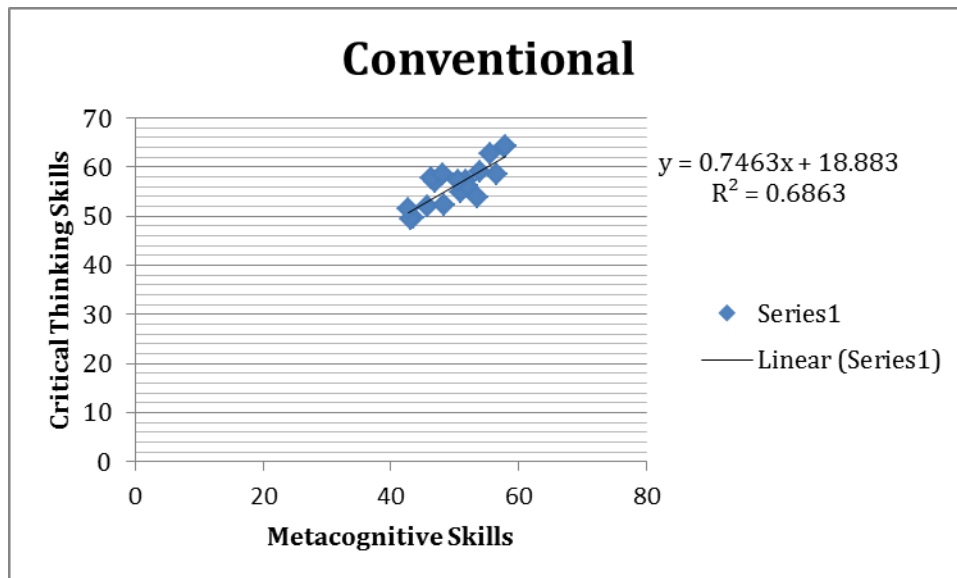| Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	18.883	6.382		2.959	.009
	MetaSkillsConv	.746	.126	.828	5.916	.000

Figure 4. Graph of regression equation between metacognitive skills and critical thinking skills in the conventional learning

The results of the data analysis in Table 10-12 show that the R value = 0.828, the F value = 34.996 with the significance value of the correlation between metacognitive skills and critical thinking skills of students as much as 0.00. This means that there is a correlation between metacognitive skills and critical thinking skills at the implementation of conventional learning strategy; the regression equation obtained is y = 0.7463x + 18.883 with the R^2 value = 0.6863; meaning that metacognitive skills have a contribution of 68.63% towards critical thinking skills, while the remaining 31.37% is the contribution of other factors in addition to metacognitive skills.

e. *Anova Test of the 4 Regression Equations of the Correlation between metacognitive Skills and critical Thinking Skills in the RQA integrated with ADI, RQA, ADI Learning Strategies and conventional Learning.*

Summary of ANOVA test of the regression equations of the correlation between metacognitive skills and critical thinking skills in the four learning strategies can be seen in Table 13. The regression equation differences of the correlation between metacognitive skills and critical thinking skills can be seen in Figure 5.

Table 13. Summary of Anova Test of the Regression Equations of the Correlation between Metacognitive Skills and Critical Thinking Skills in RQA, ADI, RQA Integrated with ADI Learning Strategies, and Conventional Learning

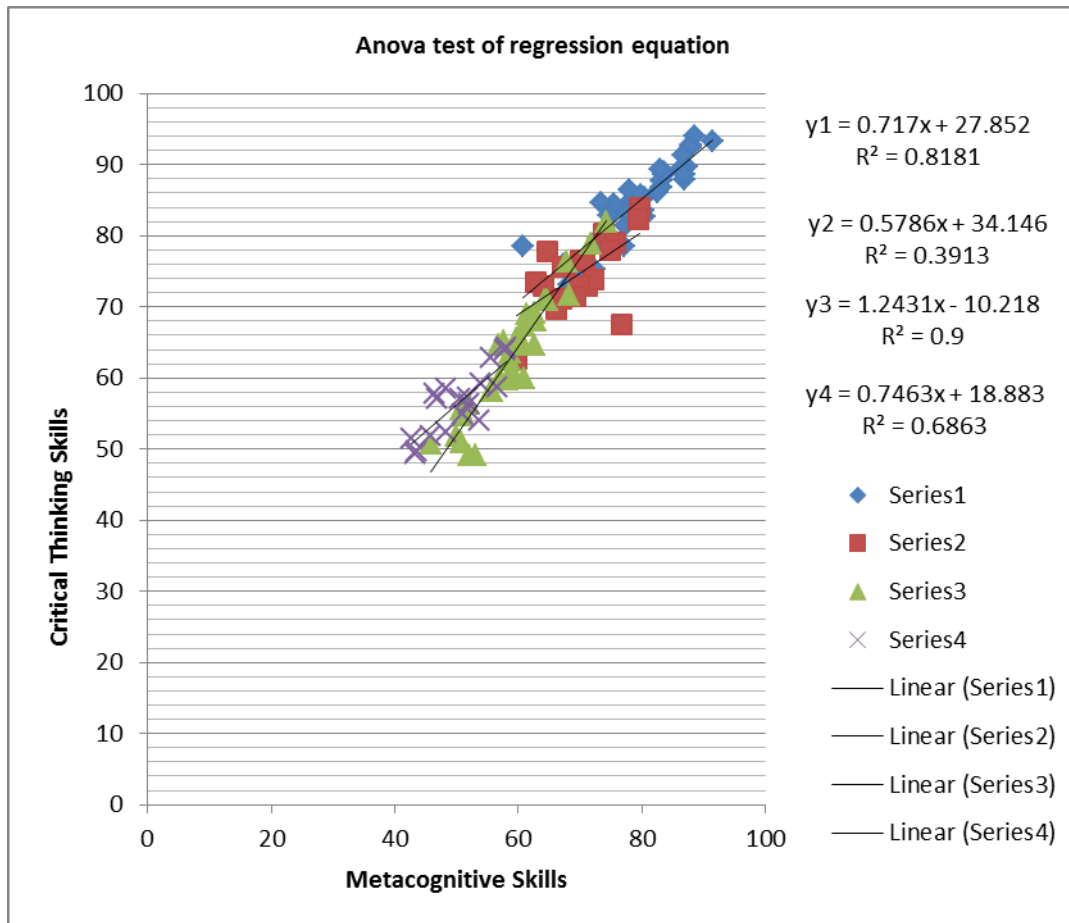| Model		Sum of Squares	df	Mean Squares	F	Sig.
1	Regression	17037.818	7	2433.974	298.407	.000[b]
	b1,b2	276.9909343	2	138.4955	6.214312	0.003
	b1,b2,b3	387.6660102	6	64.611	2.899105	0.012
	Residual	831.968	102	22.287		
	Total	17869.786	109			

Figure 5. Graph of the regression equation differences of the correlation between metacognition skills and critical Thinking Skills in the RQA integrated with ADI, RQA, ADI learning strategies and conventional learning.

Description:

Series 1 = RQA integrated with ADI learning strategy

Series 2 = RQA strategy

Series 3 = ADI strategy

Series 4 = Conventional learning

f.   Anova Test of the 2 Regression Equations of the Correlation between Metacognitive Skills and Critical Thinking Skills

The differences of the correlation between metacognitive skills and critical thinking skills in the RQA integrated with ADI, and RQA learning strategies can be seen in Fig. 6.
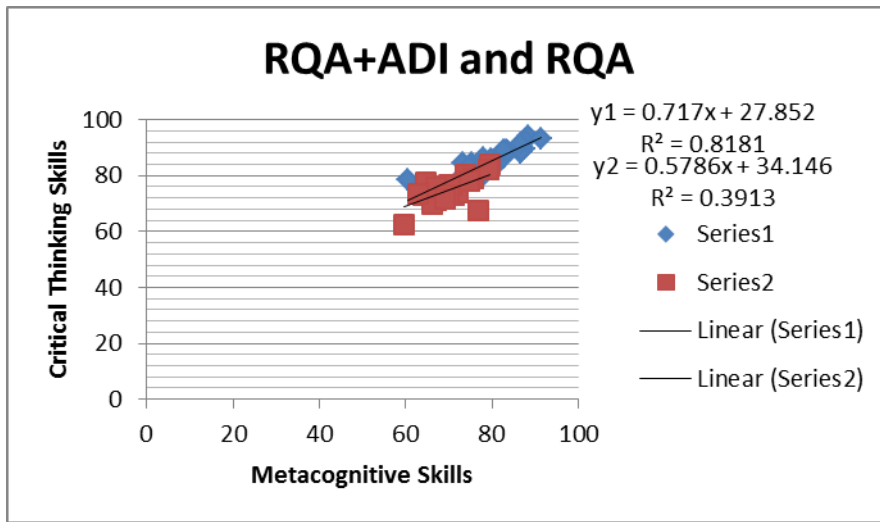
Figure 6. Graph of the difference of the correlation between metacognitive skills and critical thinking skills in the RQA integrated with ADI, and RQA learning strategies

Description:

Series 1 = RQA integrated with ADI learning strategy

Series 2 = RQA strategy

Summary of the ANOVA test of the regression equations of the correlation between metacognitive skills and critical thinking skills in the RQA integrated with ADI, and RQA learning strategies can be seen in Table 14.

Table 14. Summary of Anova Test of the Regression Equations of the Correlation between Metacognitive Skills and Critical Thinking Skills in the RQA integrated with ADI, and RQA Learning Strategies

Model		Sum of Squares	df	Mean Squares	F	Sig.
1	Regression	17037.818	7	2433.974	298.407	.000[b]
	b1,b2	276.9909343	2	138.4955	6.214312	0.003
	b1,b2,b3	387.6660102	6	64.611	2.899105	0.012
	Residual	831.968	102	22.287		
	Total	17869.786	109			

The difference of the correlation between metacognitive skills and critical thinking skills in the RQA integrated with ADI, and ADI learning strategies can be seen in Fig. 7.
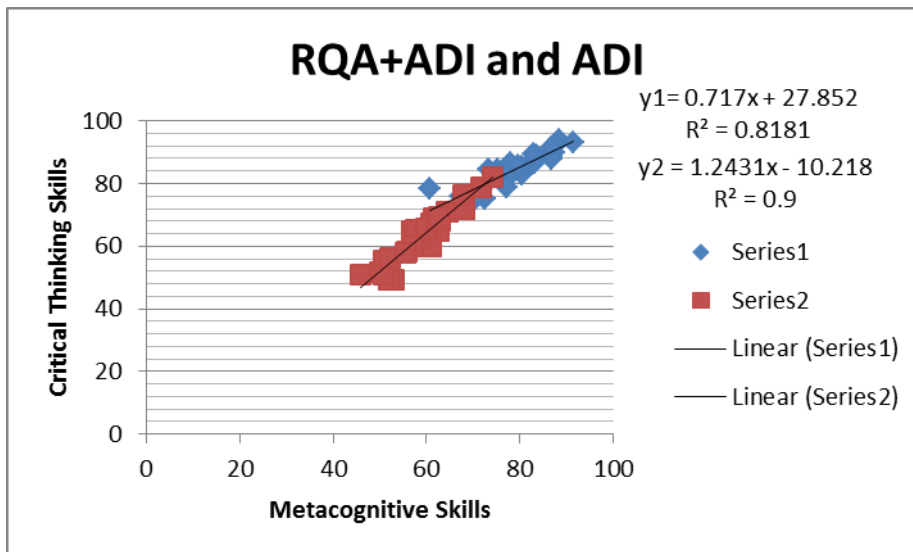

Figure 7. Graph of the difference of the correlation between metacognitive skills and critical thinking skills in the RQA integrated with ADI, and ADI learning strategies

Description:

Series 1 = RQA integrated with ADI learning strategy

Series 2 = ADI strategy

Summary of Anova of the regression equation of the correlation between metacognitive skills and critical thinking skills in the RQA integrated with ADI, and ADI learning strategies can be seen in Table 15.

Table 15. Summary of Anova Test of the Regression Equation of the Correlation between Metacognitive Skills and Critical Thinking Skills in the RQA Integrated with ADI, and ADI Learning Strategies

Model		Sum of Squares	df	Mean Squares	F	Sig.
1	Regression	11474.2	3	3824.734	600.9141	.000[b]
	b1, b2	210.338	1	210.338	33.04677	0.000
	b1, b2, b3	243.5612	2	121.7806	19.13328	0.000
	Residual	432.8104	68	6.364859		
	Total	11907.01	71			

The difference of the correlation between metacognitive skills and critical thinking skills in the RQA integrated with ADI learning strategy, and conventional learning can be seen in Fig. 8.
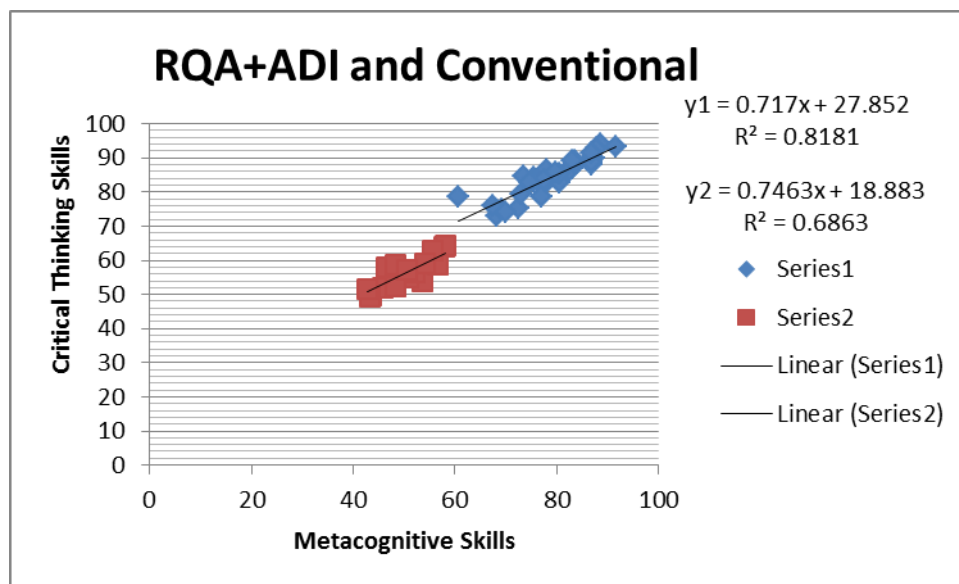

Figure 8. Graph of the difference of the correlation between metacognitive skills and critical thinking skills in the RQA integrated with ADI learning strategy, and conventional learning

Description:

Series 1 = RQA integrated with ADI learning strategy

Series 2 = Conventional learning

Summary of Anova test of the regression equation of the correlation between metacognitive skills and critical thinking skills in the RQA integrated with ADI learning strategy, and conventional learning can be seen in Table 16.

Table 16. Summary of Anova Test of the Regression Equation of the Correlation between Metacognitive Skills and Critical Thinking Skills in the RQA integrated with ADI Learning Strategy, and Conventional Learning

Model		Sum of Squares	df	Mean Squares	F	Sig.
1	Regression	11221.16	3	3740.385	621.7672	.000[b]
	b1, b2	0.29569	1	0.29569	0.049153	***0.825***
	b1, b2, b3	116.9007	2	58.45035	9.716248	0.000
	Residual	318.8338	53	6.015733		
	Total	11539.99	56			

The difference of the correlation between metacognitive skills and critical thinking skills in the RQA and ADI learning strategies can be seen in Fig. 9.
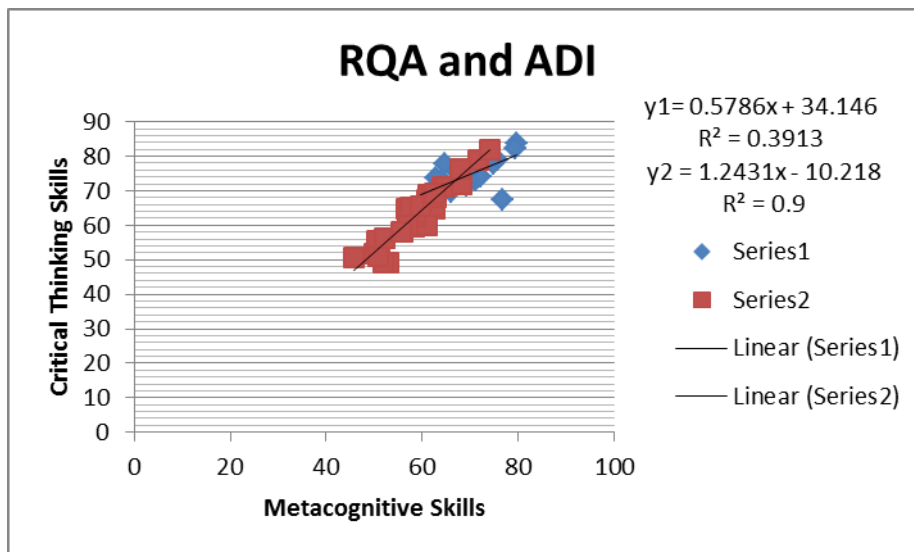

Figure 9. Graph of the difference of the correlation between metacognitive skills and critical thinking skills in the RQA and ADI learning strategies

<u>Description:</u>
Series 1 = RQA strategy
Series 2 = ADI strategy

Summary of Anova test of the regression equation of the correlation between metacognitive skills and critical thinking skills in the RQA and ADI learning strategies can be seen in Table 17.

Table 17. Summary of Anova Test of the Regression Equation of the Correlation between Metacognitive Skills and Critical Thinking Skills in the RQA and ADI Learning Strategies

Model		Sum of Squares	df	Mean Squares	F	Sig.
1	Regression	3847.888	3	1282.629	122.4804	.000[b]
	b1, b2	172.3397	1	172.3397	16.45701	0.000
	b1, b2, b3	172.3422	2	86.17111	8.228622	0.000
	Residual	513.1338	49	10.47212		
	Total	4361.022	52			

The difference of the correlation between metacognitive skills and critical thinking skills in the RQA learning strategy and conventional learning can be seen in Fig. 10.
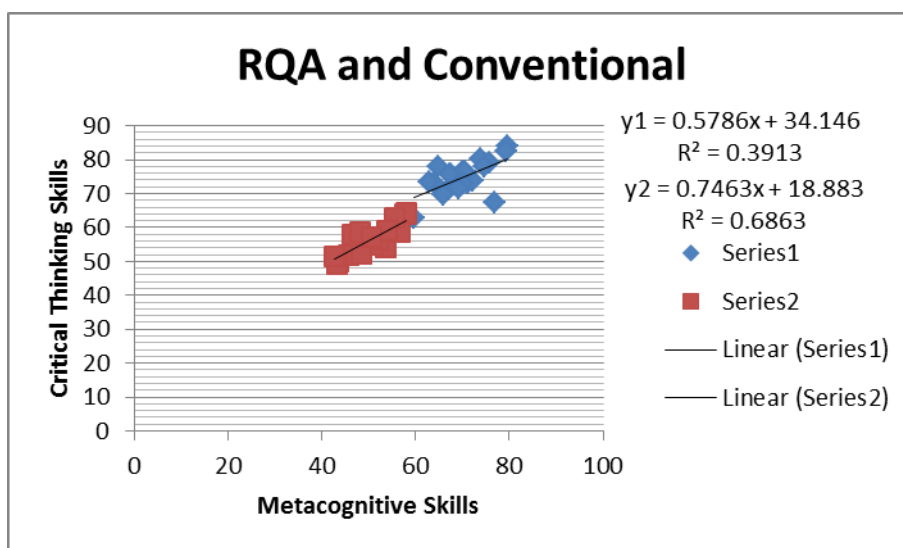

Figure 10. Graph of the difference of the correlation between metacognitive skills and critical thinking skills in the RQA learning strategy and conventional learning

Series 1 = RQA strategy

Series 2 = Conventional learning

Summary of Anova test of the regression equation of the correlation between metacognitive skills and critical thinking skills in the RQA learning strategy and conventional learning can be seen in Table 18.

Table 18. Summary of Anova Test of the Regression Equation of the Correlation between Metacognitive Skills and Critical Thinking Skills in the RQA and Conventional Learning Strategies

Model		Sum of Squares	df	Mean Squares	F	Sig.
1	Regression	3583.055	3	1194.352	101.7342	.000b
	b1, b2	6.783996	1	6.783996	0.577857	*0.453*
	b1, b2, b3	64.37747	2	32.18873	2.741819	*0.078*
	Residual	399.1573	34	11.73992		
	Total	3982.212	37			

The difference of the correlation between metacognitive skills and critical thinking skills in ADI learning strategy and conventional learning can be seen in Fig. 11.
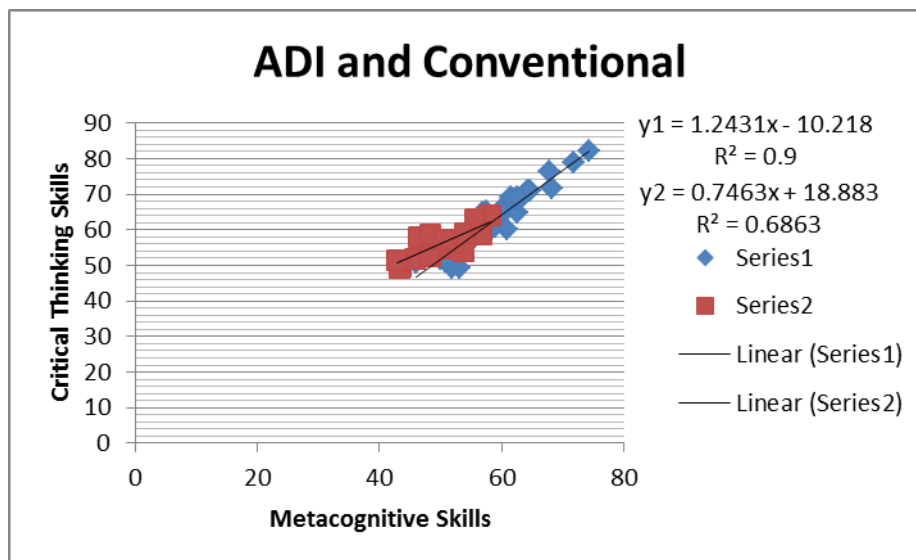

Figure 11. Graph of the difference of the correlation between metacognitive skills and critical thinking skills in the ADI learning strategy and conventional learning

Series 1 = ADI strategy

Series 2 = Conventional learning

Summary of Anova test of the regression equation of the correlation between metacognitive skills and critical thinking skills in the ADI and conventional learning strategies can be seen in Table 19.

Table 19. Summary of Anova Test of the Regression Equations of the Correlation between Metacognitive Skills and Critical Thinking Skills in the ADI and Conventional Learning Strategies

Model		Sum of Squares	df	Mean Squares	F	Sig.
1	Regression	2756.419	3	918.8064	130.8753	.000b
	b1, b2	78.81838	1	78.81838	11.22693	0.000
	b1, b2, b3	148.965	2	74.48252	10.60933	0.000
	Residual	329.9623	47	7.020474		
	Total	3086.382	50			

Discussion and Conclusion

The results of the regression analysis of the correlation between metacognitive skills and critical thinking skills in the four learning strategies show that the significance value of each learning strategy was less than 0.05. These finding mean that metacognitive skills correlate with the critical thinking skills in the four learning strategies. An increase in metacognitive skills will be followed by an increase in critical thinking skills. Conversely, a decrease in metacognitive skills will be followed by a decrease in critical thinking skills. The results of this research are consistent with the research results by Halpern (1993), showing that a person's thinking ability to control his cognitive activity, known as metacognitive skills, had a very close relationship with the students' thinking skills. The term metacognition refers to high-level mental processes that are often involved in making a study plan, monitoring the levels of learning, and predicting performance (Coutinho, Wiemer-Hastings, Skowronski, & Britt, 2005). Learners should have a positive belief and a procedural metacognition to make a plan or a program that can lead to action and involvement in the cognitive processes of thinking (Wells & Cartwright-Hatton, 2004). The success of individuals in controlling their thinking will affect their beliefs, expectations, and judgement of their mental processes and mental products (Wenzlaff & Wegner, 2000). Wicaksono (2014) revealed that there was a correlation between metacognitive skills and critical thinking toward cognitive learning results. Metacognitive skills have a significant correlation with critical thinking skills (Amiri & Ahmadi, 2014).

The correlation between metacognitive skills and critical thinking skills at the implementation of RQA learning strategy has the regression equation as y = 0.578x + 34.14 and the contribution value of 39.10%. Training the students to read analytically and critically is proven having the potency to improve their thinking skills (Mulyadi & Adlim, 2014). Reading is not only reciting what is written, but also understanding the contents of the reading as well as involving other activities such as visual, thinking, psycholinguistics and metacognitive activities. The ability to analyze and synthesize information obtained from reading activities can be done by empowering metacognitive skills and cognitive approaches (Yurdakal, 2019). The activities of summarizing and making questions can empower students' metacognitive skills (Syarifah, Indriwati, & Corebima, 2016). The activity of making questions in the RQA learning strategy has a function to improve the students' thinking ability and metacognitive skills (Darmayanti, 2015). The activity of making questions is expected to help students to convey their ideas, thoughts, and questions (Mayasari, 2014). The research conducted by Prianti (2016) reported that the RQA learning strategy affected the critical thinking skills of the Biology Education students of UNMUH Jember in the Genetics subject. Asking questions is a metacognitive activity.

The correlation between metacognitive skills and critical thinking skills at the implementation of ADI learning strategy has the regression equation as y = 1.243x – 10.21 and a contribution value of 90.00%. Kadayifci, Atasoy, and Akkus (2012) through their research at the University of Turkey found that in the ADI learning strategy there was a close correlation between the the students' weaknesses in argumentation and their critical thinking skills. This strategy requires the students to conduct *peer-review* investigation reports that are believed to develop their critical thinking skills (Sampson & Gleim, 2009; Sampson et al., 2011). The phase of *Peer-review* introduces the students about educational feedback, and it helps students to use their metacognition when working in groups. One of the ADI learning strategy strengths is creating a classroom community that values evidence and critical thinking (Amin & Corebima, 2016). The learning process emphasizing argumentation activity as found in the ADI learning strategy can make the students more active because through this activity the students connect ideas and evidence that can be used to validate their ideas and communicate them (Marhamah, Nurlaelah, & Setiawati, 2017). Thus. ADI learning strategy has the potential to create a learning environment that is more responsible for organizing the students' metacognitive skills and critical thinking skills.

The phases of the RQA and ADI learning strategies give the students the opportunities to practice their metacognitive skills and critical thinking skills. The analysis result of the correlation between metacognitive skills and critical thinking skills at the implementation of RQA integrated with ADI learning strategy has the regression equation of y = 0.717x + 27.85 and the contribution value of 81.80%. The students who have good metacognitive developments will be more capable of solving problems, making decisions, and thinking critically, more motivated to learn, more capable of managing their emotions and overcoming difficulties (Dawson, 2008). By making questions and answering the questions independently, the students become more aware of the learning results they obtain (Syarifah et al., 2016). The phase of interactive discussion facilitates the students to predict, monitor and evaluate their thoughts. The students' ability to predict, monitor and evaluate their thinking results is a metacognitive skill. The aspects of metacognitive skills can overcome difficulties in learning, whereas critical thinking provides reflective feedback (Stanton, Wong, Gore, Sevdalis, & Strub, 2011).

The correlation between metacognitive skills and critical thinking skills in the conventional learning has the regression equation of y = 0.746x + 18.88 and a contribution value of 68.60%. In conventional learning, the lecturers are more dominant in conveying information verbally. This contribution value is influenced by the condition of the students who have been accustomed to conventional learning. The students who have low learning independence achieve better learning results when taught by using conventional learning rather than TPS learning strategy (Agustinawati, 2014).

The contribution value in each learning strategy varies. This situation indicates that each learning strategy has different potential in empowering students' metacognitive skills. Fauziyah (2003) stated that there were some factors causing differences in the correlation and relative contribution related, such as learning motivation, the students' condition, and the learning environment. The differences in the regression equation of the correlation between metacognitive skills and critical thinking skills in the four learning strategies (RQA integrated with ADI, RQA, ADI and conventional learning) can be found through an Anova test of the regression equations. The regression lines were parallel but not coincide, as well as intersect. These findings mean that there is a difference in the rate and magnitude of the increase in critical thinking skills influenced by the four learning strategies.

The Anova test of the two regression equations of the correlation between metacognitive skills and critical thinking skills between RQA integrated with ADI learning strategy, and RQA learning strategy obtained the regression lines were parallel and not coincide. This means that the improvement rates of metacognitive skills and critical thinking skills in those strategies were the same, but had a different magnitude. The intercept value in the RQA learning is higher than of RQA integrated with ADI learning strategy. Therefore, the improvement of critical thinking skills influenced by metacognitive skills in RQA learning is greater than that of RQA integrated with ADI learning strategy. Similarly, the Anova test of the two regression equations between RQA integrated with ADI learning strategy, and conventional learning found that the improvement of the critical thinking skills in RQA integrated with ADI learning strategy is greater than of in the conventional learning. In addition, the Anova test of the two regression equations between RQA and conventional learning strategies found that the increase of the critical thinking skill in RQA learning strategy is greater than of conventional learning.

The Anova test of the two regression equations of the correlation between metacognitive skills and critical thinking skills between RQA integrated with ADI learning strategy, and ADI learning strategy found that the regression lines were intersecting. This finding means that the improvement rates of metacognitive skills and critical thinking skills in these strategies is different. The slope value of the ADI learning strategy is greater than that of the RQA integrated with ADI learning strategy. This finding means that the improvement of critical thinking skills influenced by metacognitive skills in ADI learning strategy is faster than that of RQA integrated with ADI learning strategy. Similarly, the Anova test between RQA strategy and ADI strategy found that the improvement of critical thinking skills in ADI learning strategy is faster than that of RQA learning strategy. The anova test of the two regression equations between ADI learning strategy and conventional learning strategy also found that the improvement of critical thinking skills in ADI learning strategy is faster than that of conventional learning strategy.

To encourage and facilitate constructivistic learning, instructors/educators must design, monitor, and review their learning in order to make the learning activities become student-centered. This is to ensure that teachers and lecturers provide meaningful learning experiences (Kabha, 2019). The empowerment of critical thinking skills, self-regulation and learning independence can improve students' learning experiences and academic achievement (Uyar, Genc, Yasar, 2018). Effective teaching strategy will have a significant contribution to students (Elban, 2018).

Many factors are affecting the slope value and intercept value such as the number of students in the classroom, the lecturer/teacher's behavior during the teaching and learning process, the students' behavior during the learning process, the implemented learning strategy and many other factors (Siswati, 2014). The quality of the learning process and learning results can be improved through the use of constructivistic learning paradigm. By constructivistic learning (including the implementation of RQA integrated with ADI strategy, RQA strategy, ADI strategy) implemented in the learning process, metacognitive ability (reflection) can be empowered, so that it is expected to improve the critical thinking skills. Developing and implementing various learning models and learning methods in learning design can improve students' thinking skills (Ichsan, Sigit, Miarsyah, Ali, Arif, Prayitno, 2019).

Based on the results of data analysis and discussion, it can be concluded that (1) there is a significant correlation between metacognitive skills and critical thinking skills at the implementation of the four learning strategies (RQA integrated with ADI, RQA, and ADI learning strategies as well as conventional learning), (2) there are parallel regression lines that do not coincide, and intersect in the regression equations tested by using Anova. These findings mean that there is a difference in the rate and magnitude of the increase in critical thinking skills influenced by the four learning strategies.

The empowerment of metacognitive skills in the learning process must be carried out optimally and continuously at every level of education. This will have some effects on students' critical thinking skills and independence. It is essential that students are equiped with these skills in order that they have the competitiveness and motivation to face the challenges of the fast-paced and digital development era. The implementation of innovative learning strategies, such as RQA, ADI, RQA integrated with ADI, can be used as an alternative for teachers and lecturers to empower students' metacognitive skills and critical thinking skills.

Suggestions

The results of the correlation analysis between metacognitive skills and critical thinking skills at the implementation of four learning strategies showed that the ADI strategies had the highest reliability value, followed by the RQA integrated

with ADI strategy. Therefore, it is recommended that lecturers and teachers use the ADI learning strategy, RQA integrated with ADI strategy to improve students' metacognitive skills and, thus critical thinking skills. Further research related to the correlation between metacognitive skills and critical thinking skills in the same or different classes, the same or different subjects and different dependent variables at the implementation of four learning strategies (RQA integrated with ADI, RQA, ADI, and conventional learning strategies) also needs to be conducted.

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