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Original Research Article

The contribution of students' metacognitive skills and scientific attitude towards their academic achievements in biology learning implementing Thinking Empowerment by Questioning (TEQ) learning integrated with inquiry learning (TEQI)

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There is no research yet investigating the correlation between students' metacognitive skills and scientific attitudes simultaneously towards their academic achievements in a class taught using TEQ learning integrated with inquiry learning (TEQI). This is a correlational research designed to investigate the contribution of metacognitive skills and scientific attitudes towards academic achievements of higher secondary school students in Malang, Indonesia. Twenty-three students participated in this correlational study. The students' metacognitive skills were measured by an essay test integrated with academic achievement measurement. The students' scientific attitudes were measured with a questionnaire. The research results showed that metacognitive skills and scientific attitudes contributed 71.42% to students' academic achievements. The contribution of metacognitive skills towards students' academic achievements was much greater (61.93%) than that of scientific attitude (9.49%). Teachers should consider implementing a learning strategy which can empower students' metacognitive skills.

Key words: Academic achievements, inquiry, metacognitive skills, scientific attitude.

INTRODUCTION

According to Eggen and Kauchak (1996), metacognition is the awareness and control of cognitive processes, while according to Peters (2000) metacognition refers to students' skills to understand and monitor their learning process. Furthermore, according to Rivers (2001), metacognition refers to the students' ability to access and manage their cognitive development, or to control their learning processes. The idea of self-regulated learning has gained a lot of attention (Zimmerman, 2001) and has become one of the most interesting area of study in the field of education psychology (Ng, 2010). According to Lai (2011), generally metacognition can be identified in young students, but it gradually becomes more specific to older students. This indicates that metacognition can be developed and trained.

According to Kardi (2005), the objective of learning is not only to provide students with knowledge, but also to help them in order to be able to control their own learning process. Nowadays, learning how to learn is a vital need of students for living in the 21st century. When a person knows how to learn, his confidence will increase. Therefore, it is essential that a student learns how to learn and how to think.

Rivers (2001) stated that metacognitive skills are

generally divided into two types: self assessment, which is students' skills to access their own cognition, and self management, which is the students' skill to manage their own cognitive development. Furthermore, he expressed that though correlate, cognitive skills and metacognitive skills were different. Cognitive skills are required to carry out a certain task, whereas metacognitive skills are required to understand how the task is carried out. Thus, metacognitive skills are related to a person's strategy in completing the tasks.

Hrbáková et al. (2012) proved that metacognition was a strong predictor of academic success for nearly as much as 90%. According to Jayapraba (2013), metacognitive strategies are the most effective ways to improve students' academic achievement. The finding supports previous finding stating that individual differences are determined by their metacognitive abilities. People having low metacognition skills are regarded as "incompetent" compared to those having high metacognition skills. In this connection Dunning et al. (2003) and Kruger and Dunning (1999) stated that metacognition skill was a strong independent variable of academic success.

In addition to metacognitive skills, scientific attitude is also believed to play an important role in students' academic success. Scientific attitude is an attitude that reflects the mindset in accordance with the rules or ethics of science. If a reaction is carried out in accordance with the ethics of science, the reaction is regarded as a scientific attitude. Scientific attitude is related to the code of conduct of scientists. Therefore, scientific attitude is used to provide the direction on a certain scientific action. Any activity relating to scientific thoughts need to be considered more carefully. Attitudes such as curiosity, rationality, willingness to suspend a judgment, open mindedness, critical thinking, objectivity, honesty and humility are scientific attitudes that regulate behaviors directed toward or away from an object or groups of objects or certain situations (Pifati and Farooq, 2012).

According to Oluwatelure and Oloruntegbe (2010), scientific attitude refers to an individual's tendency to think, feel or to react towards an object based on their beliefs about the object, either positive or negative. Thus, scientific attitude is related to the aspects of thinking in a person that happens continuously. The study by Anwer and Iqbal (2012) stated that students' gender had a significant effect on their attitudes towards science. Nolan et al. (2012) stated that students having positive attitudes toward statistics tend to show good academic performance in statistics courses. This indicates that training students' attitudes is an important aspect to be done in learning.

Scientific attitude does not only involve the cognitive components, because the non-cognitive aspects are also a part of the scientific attitude. Triandis (1971) stated that there were three main components of attitude, cognitive, affectivity and behavioral components. According to Triandis (1971), cognitive component ranks first in the scientific attitude. Therefore, scientific attitude is the supporting factor for academic achievements. This statement is in line with the findings of Mahanta (2014) stating that there is a positive correlation between students' positive attitudes and their achievement in mathematics.

According to Borich (2007), metacognitive skills are learnable. He reported that academic achievements in students taught metacognitive skills were better as they were able to develop higher order thinking. Furthermore, Boyle and Boyle (2005), Duffy et al. (1988), and Dunbsky and Metcal (2008) stated that the easiest way to teach metacognitive strategies to students was by the process of mental modeling. They further explained that mental modeling helped students to internalize the solution to different problem content. This mental modeling is required when students are asked to engage in complex tasks requiring higher-level thinking skills to support their academic achievements. Thus, metacognitive skills can be trained to the students to support their learning success.

According to George (2006), one of the key factors in science learning is the students' scientific attitude especially the development of positive attitudes towards science. This means that in addition to metacognitive skills, the scientific attitude is also an important variable in science learning. Further more Osborne (2003), Simpson and Oliver (1990), and Zhyang and Campbell, (2010) suggested that scientific attitude was one of the main concerns in science education because it had a significant correlation with academic achievement. Therefore, scientific attitudes need to be researched more in depth through the use of appropriate learning strategies.

TEQI strategy is the integration of TEQ (Thinking Empowerment by Questioning) learning and inquiry learning. This integration is designed in order to maximize these learning strategies to empower the students' metacognitive skills and their scientific attitudes. The implementation of TEQ learning, either independently or integratedly with another learning strategy, has revealed many advantages. Kristiani (2013) reported that TEQ could improve students' scientific attitude related to the lesson of "protista". Kristiani (2009) also reported that the integration of TEQ and TPS (Think Pair Share) could improve metacognitive skills and academic achievements in low achieving students. A similar research finding was also reported by Sukmawati et al. (2012) stating that TEQ could improve students' metacognitive skills, their academic achievements and retention. These findings support the fact that the implementation of TEQI can improve students' metacognitive skill, their scientific attitude and academic achievements.

Many researches have investigated the correlation between metacognitive skills and academic achievements. Bahri (2010), Atunashika (2010), Fauziah and Nurita (2010), Ardila, et al. (2013), and Mustaqim, et al. (2013) found that there was a correlation between metacognitive skills and academic achievements. This finding is

supported by Magno (2010), stating that the more students knew about effective learning strategies, the greater the metacognitiion awareness they would have and the higher the achievement they would attain. Thus, metacognition has a positive correlation with the cognitive learning results.

In addition to the findings above, the research findings about the correlation between scientific attitude and academic achievement through the implementation of various learning strategies have also been widely reported (Altun and Cakan, 2006; Kususanto et al., 2012; Li and Armstrong, 2009; and Mubeen et al., 2013). Moreover, Cornoldi (1998) stated that there was a significant correlation between the scientific attitude and the academic achievements. This was also confirmed by Shrigley (1990) stating that attitude was correlated with academic achievement. Referring to the previous research findings, it is considered necessary to investigate the multiple correlations between metacognitive skills and scientific attitudes towards academic achievements in a class taught by using TEQI learning. The results of this research will be able to reveal the contribution of metacognitive skills and scientific attitudes towards the students' academic achievements. Besides, it also reveals the contribution of both metacognitive skills and scientific attitudes simultaneously towards students' academic achievements. If the results indicate that metacognitive skills have a bigger contribution towards students' academic achievements than scientific attitude does, or vice verse, it is recommended to implement appropriate learning strategies which are able to improve that variable.

Method Samples

This study is a correlational study to determine the relationship between students metacognitive skills and scientific attitude towards their academic achievements. This correlational study was conducted from June until December 2014. The population of this study was one hundred and eighty students taken from one school. Twenty-three students of the population (13 girls and 10 oys) were randomly taken as the samples of the study, and all of the students were from urban areas. The age of students ranged between 14 to 15 years old. The students were taught using TEQI strategy. The classes used as the samples of this study were initially tested to know their equality by using a placement test consisting of 40 multiple-choice items on biology materials of the junior high school level. The analysis of the equality test was carried out by using the analysis of variance (ANOVA) using *SPSS 17.0 for Windows.*

Instrument

The instruments used to measure metacognitive skills were in the form of essay tests integrated with cognitive learning tests with as much as 25 items. The instruments used were validated before using expert validation and empirical validation. The expert validation encompassed content and construct validations. Empirical validation was carried out by testing the instruments on 36 students of class XI of Senior High School 1 Malang, Indonesia. The validity of the test items were tested using product moment correlation, and the reliability of the test items was tested by Alpha Cronbach test. The scientific attitude observation sheets were developed by the researchers referring to the Indonesian National Curriculum, in which the students had to choose yes or no towards particular statements relating to scientific attitude. The scientific attitude instruments are illustrated in Table 1.

Data collection

The data of the metacognitive skills were obtained by the essay tests integrated with cognitive learning test given before and after the learning activity. The data of the students' scientific attitude were obtained by scientific attitude observation sheets given before and after learning. The scientific attitude observation sheets were filled out by the teachers. The assessments of the students' metacognitive skills and scientific attitude were conducted from June until December 2014. The data collected were in the form of the gain score, both from the essay test related to metacognitive skills and the observation related to the scientific attitude.

The scores of the students' metacognitive skills and their scientific attitudes were not kept as a secret because the indicators and the criteria have always been informed to the students before each biology lesson begins. Before the data were collected, the purpose of this study was explained to the students, and they were asked to contribute to achieving the criteria of the metacognitive skills and scientific attitudes. Students' metacognitive skills were measured using the rubric of Corebima (2009) as presented in Table 2.

Data analysis

Hypothesis testing began with the prerequisite test to determine the normality of the data distribution. The data of this study were in the form of score of metacognitive skills as well as score of the scientific attitude obtained by observation. The data of the study were then analyzed using multiple regression analysis to examine the relationship between metacognitive skills and scientific attitude towards academic achievements by using SPSS 17.0 for Windows.

RESULTS

TEQI Learning Strategy

The results of the correlation analysis between

Table 1. Scientific Attitude Observation Sheets

Indicator		Criteria
1	Honest	1. Reporting the data in accordance with the reality or fact/ similar to the results of the observation. 2. Stating opinions or arguments based on the concrete data/ the observed data.
2	Discipline	1. Attending the experiment or the discussion both inside and outside the classrooms in accordance with the predetermined procedures. 2. Submitting the report of the experiments or the results of the discussions both inside and outside the classrooms on time.
3	Responsible	1. Accepting the consequences or the risks of the actions he or she does during the experiments or discussion both inside and outside the classrooms. 2. Collecting evidences before accepting any statements.
4	Environmental care	1. Maintaining the cleanliness especially in the site where he or she conducts experiments or discussion both inside and outside the classrooms. 2. Taking a good care of all the equipments/ materials/books/and the other learning resources
5	Cooperation	1. Flexible and open to scientific ideas. 2. Involved in the learning activities, from observing, questioning, collecting data, analyzing data, and communicating the results of the experiment/activity

Table 2. Metacognitive Skills Assessment Rubric

Score	Decription
7	The answer is written in their own sentences. The order of answer is harmonious as well as systematic. The answer is logic in correct grammar, supported by explaining reason (analytic, evaluative, or creative explanation), and the answer is correct.
6	The answer is written in their own sentences. The order of answer is harmonious as well systematic. The answer is logic in less correct grammar, supported by explaining reason (analytic, evaluative, or creative explanation), and the answer is correct.
5	The answer is written in their own sentences. The order of the answer is less/unharmonious as well as less/unsystematic. The answer is less/ not logic in less correct grammar, supported by explaining reason (analytic, evaluative, or creative explanation), and the answer is correct.
4	The answer is not written in their own sentences. The order of answer sentences is harmonious as well as systematic. The answer is logic in correct grammar, supported by explaining reason (analytic, evaluative, or creative explanation), and the answer is correct.
3	The answer is not written in their own sentences. The order of answer sentences is less/unharmonious as well as less/unsystematic. The answer is less/not logic, in less correct grammar, supported by explaining reason (analytic, evaluative, or creative explanation), and the answer is correct.
2	The answer is not written in their own sentences. The order of answer sentences is less/unharmonious as well as less/unsystematic. The answer is less/not logic, in less correct grammar, not supported by explaining reason (analytic, evaluative, or creative explanation), and the answer is less correct.
1	The answer is not written in their own sentences. The order of answer sentences is less/unharmonious as well as less/unsystematic. The answer is less/not logic, in less correct grammar, not supported by explaining reason (analytic, evaluative, or creative explanation), and the answer is not correct.
0	There is no answer at al.

metacognitive skill and scientific attitude towards academic achievements in the implementation of the TEQI learning are displayed in Table 3, 4, 5 and 6. Table 3 shows that the correlation of metacognitive skills and, scientific attitudes, towards academic achievements is very strong. Table 4 shows that the multiple regression equation is:

$$y = 0.635X1 + 0.158X2 + 22.393.$$

Table 4 also shows that the metacognitive skills variable have a strong positive effect on academic achievements ($\beta = 0.737893$, $p = 0.000$), whereas scientific attitudes also have a positive effect on academic achievements, but it is not statistically significant ($p = 0.417$). Table 3 shows a very high value for R-square (0.714). It shows that, metacognitive skills and scientific attitudes effectively contribute to academic achievements by as much as 71.4%. Based on the statistics analyses, it can be seen that in addition to metacognitive skills and scientific attitudes,

Table 3. The Summary of ANOVA of the Correlation between Students' metacognitive Skills and scientific Attitudes towards academic Achievements

	Sum of Squares	Df	Mean Squares	F	Sig.
Regression	1286.228	2	643.114	24.978	.000 [A]
Residual	514.941	20	25.747		
Total	1801.169	22			

Table 4. Regression Coefficients of the Correlation between Students' metacognitive Skills and their scientific Attitude towards academic Achievements

Coefficients [a]						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	22 393	5518		4058	.001
	MetSkillTEQI	.635	.147	.737893	4315	.000
	ScAttitude TEQI	.158	.191	.141725	.829	.417

Table 5. Summary of Regression Correlation between Students' metacognitive Skills and scientific Attitudes towards their academic Achievements

Model Summary [b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.845049 [A]	.714	.686	2.763

Table 6. Contributions of Students' metacognititve Skills and scientific Attitudes towards their academic Achievements

Variable	RC (%)	EC (%)
X1 (Metacognitive Skills) -Y (Academic Achievements)	86.72	61.93
X2 (Scientific Attitudes)) -Y (Academic Achievements)	13.28	9.49
X1 (Metacognitive Skills) and X2 (Scientific Attitudes) -Y (Academic Achievements)	100.00	71.42

28.6% of students' academic achievements is affected by other unexamined factors. Table 4 shows that metacognitive skills has an effective contribution of as much as 61.93% towards students' academic achievements, while the parameter of scientific attitude has only as much as 9.49%.

DISCUSSION

Results indicated that students' metacognitive skills and scientific attitudes contributed towards academic achievements in the implementation of TEQI learning by as much as 71.42%. Similar findings were reported by Bakar et al. (2010) stating that there was a correlation between motivation, attitudes, and academic achievements. He reported that there was a significant positive correlation between students' attitudes towards learning and motivation, as well as between students' attitudes and academic achievements. However, a non-significant negative correlation was found between students' motivation and their academic achievements. Based on the research results, it was found that the contribution of attitudes towards academic achievements was bigger compared to motivation.

Regardless of the potential of the learning strategies in improving students' scientific attitudes, in general, the use of TEQI learning in this research indicates that the contribution of students' scientific attitudes towards academic achievements is smaller compared to the contribution of metacognitive skills. The low contribution of scientific attitudes towards academic achievements in this research can be interpreted that the scientific attitudes are probably not a strong independent variable for academic achievements. This means that a high scientific attitude cannot always guarantee a high academic achievement. Whereas, scientific attitude is seen as a factor which has the most effect among the other factors (Bakar et al., 2010).

Based on the explanation above, the views expressed by Kind et al. (2007), Oluwatelure and Oloruntegbe (2010) and Salta and Tzougraki (2004), the tendency to think in ascientific attitude cannot guarantee high academic achievements. Similarly, the three main components

attached to the attitude, which are the cognitive component, affective component, and behavioral component as postulated by Triandis (1971), cannot also guarantee high academic achievements. This means that a high value of scientific attitude in a student cannot be a guarantee of higher academic achievements.

Related to the case, although most studies showed that there was a positive correlation between attitude and academic achievement, there are some other researchers who state that students' attitude might not be a significant predictor of their academic achievement. As suggested by Mickelson (1990), attitude can significantly predict a person's academic achievement, but it depends on a number of variables, especially ethnic backgrounds and social classes. Furthermore, Ma and Kishor (1997) stated that "attitude as a significant predictor of academic achievement" was indeed a paradox. Attitude may not necessarily predict a person's academic achievement because it also depends on different factors, such as race, sample selection and sample size. Those findings support the results of this research, in which scientific attitude does not have big contributions on students' academic achievements. It means that scientific attitude is not a strong independent variable for successful learning because it also depends on some other factors.

The results showed that the contribution of metacognitive skills to academic achievements is significant. This multiple correlation research reveals that the contribution of metacognitive skill towards academic achievements is far greater than scientific attitude. These research findings suggest that even though there are some other factors affecting academic achievements, metacognitive skill factor, however, needs to obtain more attention. If the students already possess good metacognitive skills, they would likely possess the other skills too. The finding of this research supports a study by Dunning et al. (2003) and Kruger and Dunning (1999) stating that metacognition was a strong independent variable of academic success. Metacognitive skill as a strong independent variable of learning achievement requires more attention. Livingston (1997) suggested that metacognitive activities such as planning on task completion, comprehension monitoring, and progress evaluation could actively control students' cognitive processes. Therefore, students having high metacognitive skills are also guaranteed to have high academic achievements. Thus, the findings of Coutinho (2007), Kristiani (2009), Atunasikha (2010), Fauziah and Nurita (2010), Ardila, et al. (2013), and Mustaqim et al., (2013) stating that there was a correlation between metacognitive skills and academic achievements supports the statement. It is also in line with the findings of Ainley et al. (2006), and Camahalan (2000) which stated that there was a significant positive correlation between academic achievement and the use of self-regulation strategy. Similarly, the research findings of Listiani et al. (2014) showed that metacognition had an effect on students' academic achievements. This finding is also in line with Taylor (1999) who stated that metacognition was an appreciation of what they already knew, what knowledge and skills were necessary to be combined into a strategy used for a particular situation, so that they could perform efficiently and reliably. Furthermore, Lin (2001) stated that metacognition was the ability to understand and monitor our own mind that was also the assumptions and the implications of our activities. Metacognition is an activity that reminds and controls one's cognition. Thus, according to Livingston (1997), metacognitive strategies might be similar to cognitive strategies. Therefore, it is believed that metacognitive skills are a strong independent variable of academic achievements.

Lin (2001) revealed that metacognition provided people the ability to understand and to monitor their own thoughts and assumptions which were the implications of the people's activities. Based on the statement, the attitude can be facilitated by the mastery of metacognitive skills, which means that if students have high metacognitive skills, they will be able to increase their positive attitudes. Thus, metacognitive skill can improve not only students' scientific attitudes but also their cognitive learning results. Therefore, it is essential to pay more attention to metacognitive skills in learning activities.

Referring to the above discussion, teachers need to consider the implementation of TEQI learning strategy. This learning strategy does not only concern the academic achievements, but also empower students' metacognitive skills and increase students' scientific attitudes.

Conclusion

Based on the findings and discussion above, it can be concluded that the contribution of metacognitive skills and scientific attitudes simultaneously towards academic achievements in the implementation of TEQI strategy is very high. Besides, it is also revealed that the contribution of metacognitive skills towards academic achievements is much greater than scientific attitudes.

Recommendation

Teachers should also place more attention on the empowerment of students' metacognitive skills through the implementation of appropriate learning strategies, because the contribution of metacognitive skills towards students' academic success is very high, even much higher than the contribution of scientific attitudes towards academic achievements. There are two recommendations more proposed based on the research results.

1. TEQI learning strategy, which is known to be able to develop students' metacognition skill and their scientific attitudes as well as their academic achievements, needs to be taken into account in selecting learning strategies.
2. Further researchers can conduct similar studies in

different schools of different background and environment, either in urban or rural areas.

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