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STUDENTS' METACOGNITIVE AND CRITICAL THINKING SKILLS IN THERMOCHEMISTRY

Sudirman[1*] and Yusnaeni[2]
[1]Department of Chemistry Education, University of Nusa Cendana, St. Adisucipto Penfui, Kupang NTT, 85001, Indonesia
[2]Department of Biology Education, University of Nusa Cendana, St. Adisucipto Penfui, Kupang NTT, 85001, Indonesia
[*]Email: sudirman_bandu@staf.undana.ac.id

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ABSTRACT

Metacognitive is the ability to control cognitive aspects, while critical thinking is the ability to think rationally and clearly in understanding the logical connections between various ideas. Both are necessary in 21st -century education. This study aims to analyze students' metacognitive and their critical thinking skills in thermochemistry material and the correlation of metacognitive with critical thinking. The population was the third-grade private high school students consisted of four schools. Each school was randomly selected by one class as a sample, with a total sample of 150 students. Metacognitive skills instrument is an integrated essay test of metacognitive skills and critical thinking. The results showed that most of the students' metacognitive skills in the developing category (51.67%), most of the students' critical thinking skills in the sufficient category (65.33%), the students' metacognitive and critical thinking skill are positively correlated. The contribution of metacognitive abilities to critical thinking is at 72.0%. The results indicate that students' metacognitive and critical thinking skills need to be empowered to improving the quality of learning.

Keywords: critical thinking ability, empowering, metacognitive skills

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1. INTRODUCTION

Progress of a nation can be seen from the quality of education. Education is the process of giving birth to qualified future generations. Indonesia is one of developing countries which still had problems in the world of education. Qualified education is education that is able to revive itself and be able to compete with other nations.

The quality of education in Indonesia is still low, as seen from several indicators, namely: 1) the ability of students to absorb subjects is not optimal, 2) the lack of ability to form character which is reflected in low attitudes and life skills, and 3) the ability to read, write and numerate especially in basic education is still weak. Based on the United Nations Educational, Scientific and Cultural Organization (UNESCO) survey, on the quality of education in developing countries in Asia Pacific, Indonesia ranks 10th out of 14 countries. Especially in the Province of East Nusa Tenggara (NTT), including in Ende District, the graduation rate of schools in NTT is still at the lowest level (BPS, 2013).

The low quality of education is influenced by many factors, one of which is the students' factor, in this case related to their thinking ability. Thinking is needed by humans in everyday life. Through thinking humans can recognize problems, understand and solve them. Thinking is the first step in learning. The thinking skills that need to be empowered in

students are higher order thinking skills, including the ability to metacognitive and critical thinking. Metacognitive skills are important in learning and are a determinant of academic success. Students who have good metacognition show good academic success also compared to students who have poor metacognition, as reported by Siburian (2019), Yusnaeni (2017), Bahri (2015), and Aprilia (2013). Individual differences persist in metacognition. Students who have poor metacognition tend to be incompetent. However, students with poor metacognition can be improved through metacognitive training as well as their academic success.

According to O'Neil and Brown (O'Neil Jr, 1997) metacognition is the process of thinking about their own thinking in order to build strategies for solving problems. In line with that, Blakey and Spence (Blakey, 1990). Livingston also adds that metacognition is a process of thinking about thinking and learning how to learn (Livingston, 1997).

Apart from metacognitive skills, critical thinking skills are also an important aspect of high order thinking skills. Critical thinking is a reasoned and reflective way of thinking by emphasizing making decisions about what to believe and do (Ennis, 1993). Bayer (1995) also reveals that critical thinking is way of thinking by making reasonable judgments, with certain criteria (Wade, 1995) which includes formulating and limiting problems, researching data, analyzing, interpreting, being objective, not exaggerating and unambiguous. Furthermore, Ennis (1993) adds that critical thinking includes character and skills. Several studies on critical thinking skills have been conducted by Istianah (Istianah, 2013) and Ristiasari (2012). Istianah more specifically reported how to foster students' critical thinking skills by approaching MEAs, while Ristiasari reported about critical thinking through the application of the PBL model. The results of this study indicate the importance of critical thinking skills in students.

The development of metacognitive abilities and critical thinking in the learning process is a very important effort to do. For this reason, the initial analysis of students' metacognition skills and critical thinking skills needs to be mapped in order to obtain more accurate information about efforts to empower their thinking abilities. On the other hand, information about the correlation between the two thinking abilities needs to be done to see how big the relationship between the two is. This is in accordance with one of the goals of higher education, namely transforming and developing student abilities, including to design what will be done, carry out what has been planned, monitor and evaluate what is and has been done, so that they be critical, creative, innovative, independent, confident, and responsible.

2. RESEARCH METHOD

2.1 Types of Research

This research is a correlational study that aims to reveal the relationship between metacognitive skills as an influencing factor with students' critical thinking skills. Correlation research uses descriptive methods to describe the relationship between students' metacognitive thinking skills and critical thinking on thermochemistry.

2.2 Population and Sample

The study population was the third graders in natural sciences at a private high school in Ende Regency, which were spread over 4 research sample schools. The sample was taken one class per school. Sampling was done by random sampling in the third grade of natural sciences. The total sample is 150 students.

2.3 Research Instruments

The data collection instrument was in the form of an integrated essay question to measure how much the students' metacognitive abilities and the chemical critical thinking questions used were subjective questions in the form of an essay after they were taught thermochemistry. Metacognitive skills are assessed based on the rubric developed by Corebima (Corebima, 2009), while critical thinking skills are assessed based on Ennis & Weir (1985). The instrument has previously been validated and its reliability has been tested.

2.4 Research Procedure

Data were collected by providing an integrated test of metacognitive skills and critical thinking to a sample of students. Before the test instrument is given, it is validated by an expert validator and tested on students. The validation results obtained valid and reliable questions to be used as a data collection instrument.

2.5 Data Analysis Technique

The data obtained were analyzed descriptively to determine the categories of metacognitive skills and critical thinking. Meanwhile the correlation between metacognitive skills and critical thinking used product moment correlation analysis, with the prerequisite test for normality and homogeneity (Supardi, 2013).

The categorization of the level of metacognitive skills refers to Suratno (2010), namely *super* (85-100), ok (68-84), *developing* (51-67), *can't really* (34-50), *at risk* (17-33), and *not yet* (0-16). By way of explanation: Not yet: not yet leading to metacognition, at risk: seems to have no awareness of thinking as a process, can't really: unable to separate what can be thought from how it thinks, developing: can help towards awareness of thinking on one's own if encouraged and supported, ok: conscious of thinking on his own and can distinguish the stages of input-elaboration-output of his own thoughts. Sometimes using models to regulate their own thinking and learning, and super: use metacognitive awareness regularly to regulate their own thinking and learning processes, while categorizing students' critical thinking ability levels refers to Riduwan (2011), namely: 81 - 100 (Very high), 61 - 80 (high), 41 - 60 (sufficient), 21 - 40 (low), and 0 - 20 (very low).

3. RESULT AND DICUSSION

3.1 Description of Students' Metacognitive Skills

The results of the descriptive analysis of the data on the results of the tests carried out after being taught thermochemistry, obtained the percentage of students' metacognitive skills based on their categories, can be seen in Figure 1.

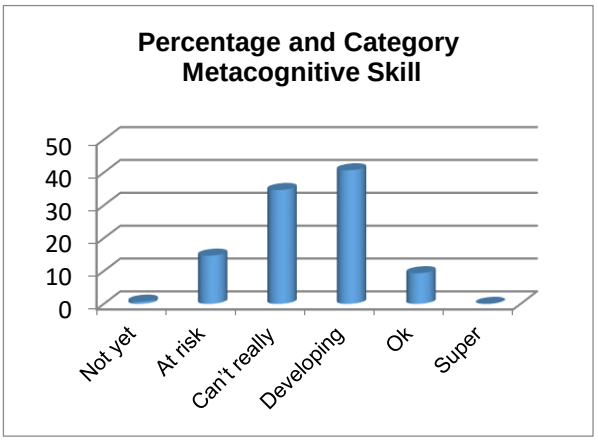

Figure 1. Percentage and Category of Metacognitive Skills of Private High School Students in Thermochemistry

Figure 1 shows that of the 150 students who took the metacognitive skills test, no student (0%) was in the *Super* category, and the highest percentage for students' metacognitive skills was in the *Developing* category at 40.67%. The results of the analysis based on data per school and data per student show that the average metacognitive skills of students have not yet developed (*can't really, at risk and yet*) with a total of 50.01%. These results indicate that students have not been able to use their metacognitive abilities regularly to regulate their own thinking and learning processes. Meanwhile, 14 students (9.33%) are in the ok category, which means these students are aware of their own thinking and can distinguish between the input-elaboration-output stages of their own thoughts and sometimes use models to organize their own thinking and learning.

The results of the data analysis showed that the metacognitive abilities of students at six private schools in ende to be precise in thermochemistry material were still classified as underdeveloped (can't really, at risk and yet). This indicates that students' metacognitive thinking skills should be cultivated and empowered, given that metacognitive thinking skills are closely related to other higher-order thinking skills,

namely critical thinking skills. The ability to think metacognitive at an underdeveloped stage indicates that in learning, students do not have the awareness of thinking as a process and are unable to separate what can be thought from how they think. In this condition, students should ideally be guided and directed through a series of learning innovations that seek to improve their metacognitive abilities. When their metacognitive abilities are empowered, individuals tend to be able to adjust their behavior, and know their strengths and weaknesses. Skilled / expert learners consider their learning objectives as planned and monitor their own learning and implement according to their plans. One of the forms of learning innovation that can empower students 'metacognitive thinking skills has been reported by Yusnaeni (2017), where using an innovative problem-based learning model can improve students' metacognitive thinking skills and improve student learning outcomes (Yusnaeni., 2018) and improve creative thinking skills (Yusnaeni., 2017).

The characteristics of thermochemistry which are conceptual and contain allogarithmic elements make it difficult for some students to connect the relationships between the sub-material parts studied in thermochemistry. Because of the characteristics of thermochemistry require students to have the ability to think critically and metacognitively. Describing students' metacognitive and critical thinking abilities after being taught this material is the first step to determine the right strategy in teaching this material further, so that both thinking abilities can be developed.

The research results of Sudjana and Wijayanti (Sudjana, 2018) reveal that when students are taught using certain learning strategies, in this case the application of problem solving learning models can actually empower students 'metacognitive abilities in solubility material which is marked by an increase in the average score of students' metacognitive abilities.

Students whose metacognitive abilities are empowered will become students with Self-Regulated Learning abilities (self-regulating learning). Self - Regulated Learning begins with setting plans and goals by considering time constraints. Strengths and weaknesses are relevant to the learning task and motivation to learn. After setting reasonable goals and planning a learning strategy, the learner sets himself up and then applies the plan, monitoring the results as he learns. If the strategy chosen works well, he will move on. If not, he makes adjustments and monitors the results until they align with his learning goals.

The results of this study mean that metacognitive plays a role in the stage of students' thinking ability. As revealed by Livingston that metacognitive plays an important role in learning. Metacognitive leads to higher order thinking skills.

Activities that involve analysis, synthesis and evaluation are fundamental to the implementation of metacognitive skills. For this reason, learning by empowering students' metacognitive abilities really needs to be done as an effort to improve other higher-order thinking skills in this case critical thinking. This is in line with (Nugraha, 2019) that metacognitive approaches can improve students' critical thinking skills. The development of students' metacognitive abilities needs to be done so that students are able to plan, control and evaluate their own learning activities so that in the end they can become independent learners. This is supported by Miranda (Miranda, 2010) that learning will be qualified if students are consciously able to control their cognitive processes and have an impact on increasing their metacognitive abilities.

3.2 Description of Students' Critical Thinking Skill

The results of percentage of students' critical thinking tests based on their categories after being taught thermochemistry, can be seen in Figure 2.

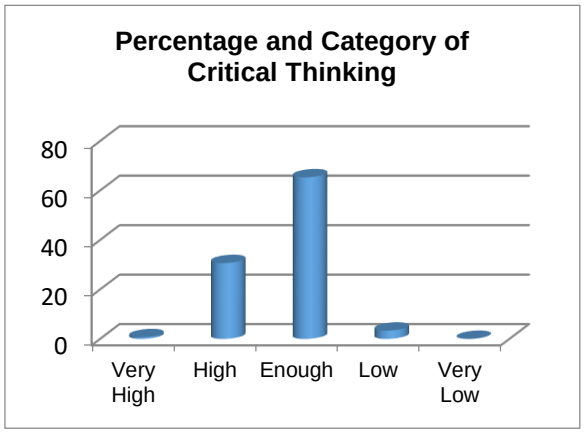

Figure 2. Percentage and Category of Critical Thinking Skills of Private High School Students in Thermochemistry

The results of the study in Figure 2 indicate that the critical thinking skills of private high school students in thermochemistry still need to be improved. Critical thinking skill, it can be trained in various opportunities through the teaching and learning process. By creating a learning environment that supports the creation of critical thinking skills.

The results of data analysis on students' critical thinking skills indicated that most private high school students have not yet empowered their critical thinking skills. This case can be seen during the learning process where the students' ability to answer questions about critical thinking skills is still very low, in another word, they can only formulate the main problems and reveal the facts. The results of this study are also in line with those reported by (Yunita, 2018) where students' critical thinking skills are only 15.6% at a high level, and the largest percentage is at the high level. When it comes to choosing logical arguments and detecting biases from different points of view, they can't, in the sense of just putting it up. If we refer to the indicators of critical thinking according to Ennis (1993), namely being able to: 1) formulate problem points, 2) reveal existing facts, 3) choose logical arguments, 4) detect bias with different points of view, and 5) determine the consequences of a statement taken as a decision, the critical thinking ability of private students at Ende is still at a low level because it only fulfills two indicators. Meanwhile, according to Siswono (Siswono, 2011), the ability to think critically is high if it meets four or five indicators from Ennis (1993).

3.3 Result

Furthermore, Yildirim and Ozkahraman (Yildirim, 2011) revealed that critical thinking is the process of seeking, obtaining, evaluating, analyzing, synchronizing and conceptualizing information as a guideline for developing one's thinking with self-awareness, and the ability to use this information by adding creativity and taking risks. Iakovos (Lakovos, 2011) added that critical thinking has an important role in education and is the main goal in learning where there are four important components to build this ability, namely (a) explaining and clarifying; (b) asking appropriate clarifying questions or challenges; (c) considering the credibility of the source; (d) solving problems and drawing conclusions.

3.4 Correlation of Metacognitive Skills with Students' Critical Thinking Ability

The results of the data normality test for metacognitive skills and students 'critical thinking skills using the Kolmogrof-Smirnov Z test obtained normally distributed data with a value of 0.893 and 0.84 respectively. Furthermore, the results of the data homogeneity test for metacognitive skills and students' critical thinking skills were based on the Levene test. The data obtained were distributed with homogeneous variances with values of 0.605 and 0.174, respectively. Normal and homogeneous if the sig value> 0.05.

Furthermore, the summary of the results of the regression analysis of the relationship between metacognitive skills and critical thinking skills of students can be seen in Table 1.

Table 1. The Summary of Regression between Metacognitive Skills and Critical Thinking Abilities of Students in Thermochemical Material

Model	R	R-Square	Adjusted R-Square	Std. Error of the Estimate
1	.265[a]	.702	.064	9.37071

3.5 Predictors: (Constant), Metacognitive Skill

Table 1 shows that the results of the regression analysis of the relationship between metacognitive abilities and students' critical thinking abilities obtained an R-square value of 0.072. The value showed that the reliability of metacognitive abilities on critical thinking skills was 72%. The rest (28%) was caused by other factors. Furthermore, a summary of the relationship between metacognitive abilities and critical thinking skills is presented in Table 2.

Table 2. Anova Summary the Relationship between Metacognitive and Critical Thinking Skills of Students in Thermochemistry

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	981.353	1	981.35	11.17	.001[a]
Residual	12995.914	148	87.81		
Total	13977.267	149			

a. Predictors: (Constant), Metacognitive Skill
b. Dependent Variable: Critical Thinking Skill

Table 2 shows that the significance value is 0.001 with an F of 11.17. These results indicate that there is a significant relationship between metacognitive abilities and students' critical thinking abilities because the significance value (0.001) is less than 0.05 (sig. Level <0.05).

Table 3 then contains a summary of the regression coefficients of the relationship between metacognitive abilities and critical thinking skills.

Table 3. Regression Coefficient of Metacognitive and Critical Thinking Skills of Students in Thermochemical Material

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
Constant					
Metacog	47.78	2.686		17.79	.00
Critical	.174	.052	.265	3.343	.00

3.6 Dependent Variable: Critical Thinking Skill

Based on Table 3, a regression equation can be made for the relationship in question, namely Y = 47.78 + 0.174X. Overall, it can be seen that metacognitive abilities and critical thinking abilities are positively correlated. This means that if students' metacognitive abilities are high, their critical thinking abilities will also increase.

The results of the correlation test show that between metacognitive thinking and critical thinking has a positive relationship. This provides evidence that if metacognitive abilities are empowered in students, it will support the growth of critical thinking abilities. This is in line with Page [28] saying that critical thinking is related to higher-order cognitive thinking. And it should be noted that metacognition as described by Gagne is a high-level cognitive process that directs students to the ability to solve problems, make decisions and think critically.

Based on the opinion of some of these experts, it is clear that there is a strong relationship between metacognitive thinking skills and critical thinking skills. Therefore, it is the duty and responsibility of the teacher to create a learning environment that can foster both types of thinking skills so that students are accustomed to a culture of critical thinking in solving problems. This is in line with (Mc Murarry, 1991) who revealed that critical thinking is a very important activity to be developed in schools, teachers are expected to be able to realize learning that activates and

develops critical thinking skills in students. This is also in line with the opinion of Schaferman (Scaferman, 1999) that learning planning by teachers for the development of students' critical thinking skills is a necessity to be implemented.

The final assumption that can be given from the results of this study is that metacognitive and critical thinking skills are higher-order thinking skills that can be used in the formation of students' conceptual systems. Conceptual formation in chemistry learning, especially thermochemical material is very necessary because this material is conceptual and contains allogarithmic elements. On the other hand, thermochemistry also requires the ability to correlate the relationships between the sub-material parts that are studied in thermochemistry. When this thinking ability is still at a low level, it will be very difficult for students to understand thermochemistry, because they have difficulty in drawing relationships or correlating to the material being taught. Therefore, by knowing the two categories of higher order thinking skills, the teacher can determine the right learning strategy to use so that students can achieve the expected learning objectives.

4. CONCLUSION

Some conclusions in this study are: The percentages of students' metacognitive skills in some categories are: not yet 0.67%, at risk 14.67%, can't really 34.67%, developing 51.67% and ok 9.33%.The percentages of students' critical thinking abilities in some categories are: very high 0.67%, high 30.33%, sufficient 65.33%, and low 3.33%. There is a positive correlation between metacognitive skills and students' critical thinking abilities. The regression equation for this correlation is Y = 47.781 + 0.174X.The contribution given by metacognitive skills to critical thinking skills is 72.0% and the rest is determined by other variables.

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