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Relationship of metacognitive skills, critical thinking, and students' knowledge of ecosystem concepts

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ABSTRACT

Metacognition and knowledge of ecosystem concepts with critical thinking is a self-learning process of critical learning toward certain objects, which are ecosystem components. The research analyzes the relationship between metacognitive skills, knowledge of ecosystem concepts, and critical thinking skills. The research is carried out at MAN 1 Tangerang from May to August 2021, involving 65 Class XI IPA-1 and XI IPA-2 students. The students are selected using a simple random sampling technique. The instrument consists of variables of metacognitive ability (X1), knowledge of ecosystem concepts (X2), and critical thinking (Y), each of which consists of 15 description questions. Thus, the total number of research samples is 195. The instrument used is an essay test that is distributed online and offline. The research method is a correlation study. The results indicate that there is no positive relationship between metacognitive skills and critical thinking with a correlation of 0.016, there is a positive relationship between knowledge of ecosystem concepts and critical thinking with a correlation of 0.490, and there is a positive and simultaneous relationship between metacognitive skills and knowledge of ecosystem concepts and critical thinking.

Introduction

A country's human resources potential and skills will be indicated by its education system. The education system in Indonesia is imperative in human resources' potential development and enhancement according to the state goal of achieving public prosperity and enriching the lives of the nation. The current development of natural sciences and technology will essentially influence the advancement of an education system. This requires sustainably developed efforts to provide larger

benefits for the surrounding society. Developing the demanded competencies will require students to have metacognitive knowledge that will direct their knowledge and cognition to develop problem-solving skills useful for future life (Lestari et al., 2017).

Science and technology-based education can be developed when students must be able to motivate themselves to work as a team or group, to act creatively and innovatively in determining various ideas or issues in several disciplines as creative learners; hence, the students can experiment through different methods. The enhancement of student understanding of a concept can be established through a learning process. The success of a learning process in a teaching and learning activity at school is indicated by the student's achievement in the form of an assessment that includes knowledge aspect, skills, ability to act, and development of self-character attitudes and values consisting of behavioral character.

A monotonous learning activity makes students less able to develop self-skills in thinking, especially their metacognitive skills. Consequently, they struggle to solve a problem. One of the causes of the difficulty in solving a problem is minimum thinking skills in students about concepts conveyed, which is a concept (idea) that is not originated from the students but is taken from the book and teacher's ideas, thus leading to the less maximum achievement of concept mastery. This stimulates the learning process and allows the students to develop their potential in critical thinking to solve a problem (Fitri et al., 2019).

Learning activity is an interaction process experienced by an individual to achieve goals to acquire changes in new behaviors as a whole with the full awareness that brings good impacts on each student to socialize with their environment. The learning process will go well if a design has been previously and intentionally planned to achieve learning objectives meaningful for the students (Ramdiah & Adawiyah, 2018). Metacognitive skills are high-order thinking skills on how to think that involve a cognitive process, (Livingston, 1997 as cited in Rosyida et al., 2016) that metacognitive skills can generate a high academic score for students. Additionally, metacognitive skills are high-order thinking skills on how to think that involve cognitive processes with three components, namely planning, monitoring, and evaluating, and have a positive relationship with academic achievement (Afoan & Corebima, 2018; Sukarelawan et al., 2021). Therefore, it is necessary that learning at school must empower metacognitive skills; thus, it can improve students' cognitive academic achievement (Rosyida et al., 2016).

Metacognition is knowledge of self-learning or how is the learning process. Thinking skills and study skills are an example of metacognitive thinking skills. Students can be taught various methods to possess self-understanding by finding out the amount of time needed to learn something and selecting effective measures to learn or solve questions. Moreover, metacognitive skills are required to achieve learning success, considering they allow students to manage cognitive skills and discover their weaknesses to improve them in the next actions (Eriawati, 2015). Hidayat (2021) elaborates on metacognition as one's skills in learning that comprise how the learning process should be conducted and what has been known or unknown through three stages, namely planning, monitoring, and evaluation. In addition, metacognition has two primary components: metacognitive knowledge and experience or metacognitive regulation. Metacognitive knowledge relates to our knowledge of ourselves and awareness of the thinking strategies use. In contrast, metacognitive experience is an experience and thinking attitude that occurs before, after, or during the thinking activities.

Metacognitive skills are used as learning motivation and are considered significant in cognitive activities that include understanding a learning process (Hidayat, 2021). Therefore, metacognitive skills lead to high-order thinking skills that consist of active control of the cognitive process in learning. Learning activities include planning how to complete assignments given, monitoring understanding, and evaluating cognitive development, which is metacognition that occurs every day that allows students to conduct planning, follow development, and monitor processes (Usman et al., 2017). Metacognitive strategies are high-order skills that benefit from the knowledge of

cognitive processes and constitute an attempt to regulate one's learning through planning, monitoring, and evaluating.

Metacognitive learners can recognize when they are not learning effectively and choose the most appropriate strategy to improve their learning processes and outcomes (Alexander, 2008 as cited in Kaya et al., 2022). Metacognition significantly influences critical thinking (Carvalho and Santos (2022), which determines the importance of considering it in educational curricula, especially in secondary education (Akhan, 2021). Higher-order thinking involved in inference-making interpretation, and evaluation of arguments is therefore promoted if metacognition is activated (Gómez-Barreto et al., 2020; Ku & Ho, 2010) , so leading to a maximization of learning (Carvalho & Santos, 2022).

Critical thinking is rational and reflective thinking emphasizing decision-making on what must be believed or done. It is a mental process to analyze or evaluate information. The information can be generated from observation results, experiences, deduction-induction processes, or communication. Critical thinking skills are measured using instruments developed through critical thinking aspects and indicators (Anggereini & Irawan, 2016). Critical thinking is an intellectual process of creating concepts, implementing, synthesizing, and/or evaluating information gained from observation, experiences, reflection, thinking, or communication as a foundation to believe in and perform an action. As a cognitive skill, it contains activities of interpretation, analysis, evaluation, inference, explanation, and self-regulation (Gómez-Barreto et al., 2020). Critical thinking means that an individual feature his/her such intellectual skills as reasoning, analyzing, problem-solving, reading comprehension, scientific thinking, creative thinking, judgment, and deciding accurately (Sarigoz, 2012). Students' critical thinking disposition was positively related to their creative self-concept and scientific creativity (Qiang et al., 2020), that is their ability to generate new products or ideas of scientific value (Álvarez-Huerta et al., 2022).

Ennis (2011) state that critical thinking is reasoning thinking and reflective thinking directed to decide convincing things to do. Moreover, Rustaman (2011) opines that critical thinking is important to master since it is one of the higher-order thinking skills that must be developed and is an alternative to developing student characters in science education. Additionally, critical thinking skills emphasized in learning are the learning outcome (Erikson & Erikson, 2018). Critical thinking as an active, continuous, and thorough consideration process on a belief or a form of knowledge that is taken for granted by including supporting reasons and rational conclusions (Wayudi et al., 2020; Whiley et al., 2017). Critical thinking skill is thinking that is always curious about existing information to achieve deep understanding (Bierer et al., 2008). Critical thinking skill is consists of interpretation, analysis, inference, evaluation, explanation, and self-regulation (Facione, 2011; Yustyan et al., 2016).

Determining or measuring intellectual skills or critical thinking skills, such as memorizing skills and problem-solving skills, can be done by determining their cognitive domain. The revised Bloom Taxonomy (remembering, understanding, application, analysis, evaluation, and creating) is often used in depicting the improvement of cognitive skill complexity when students move forward from a beginner level to a higher level of their knowledge (Ambiya & Panyahuti, 2020). The development of critical thinking skills in students' learning process can be one of the methods to improve student's learning achievement.

Critical thinking skills invite students to play an active and effective role in solving problems faced. Previous studies that examine the relationship between one independent variable and one dependent variable suggested that there was a relationship between critical thinking skills and learning outcomes (Malahayati et al., 2015). Critical thinking could highly foster and develop by using learning materials, such as skill training, learning on the network, organizing activities, or a learning environment promoting critical thinking (Magpantay & Pasia, 2022). In addition, collaborative learning techniques to solve problems are also a method encouraging learners to develop critical thinking (Kwangmuang et al., 2021).

Biology is one of the knowledge branches that plays a primary role in the continuity of human activities with other

living things in their surrounding environment. Students can gain numerous benefits in learning with metacognitive awareness and high critical thinking by reflecting on them in everyday life. Critical thinking in biology learning activity aims to get appropriate direction in the understanding of the subject matter. It is a skill to think rationally and reflectively according to what is believed and done. Achieving several targeted competencies will require students, as 21st-century human resources, to enhance learning process quality, namely improvement of the teaching system and teachers' skill quality (Şen & Vekli, 2016).

Critical thinking skills can be used as a thinking skill to analyze environmental problems based on environmental education applications. Students need critical thinking skills in developing their knowledge. Moreover, these skills are also required in community life since humans always face problems every day (Putri et al., 2018). The low metacognitive skills and knowledge understanding of ecosystem concepts as well as critical thinking are problems in biology study learning at the secondary level. This has implications for the low students' learning achievement. The fact, however, indicates that students' metacognitive skills and critical thinking have not developed appropriately leading to poor learning achievement. The description suggests that students' metacognitive skills, knowledge of ecosystem concepts, and critical thinking are crucial in providing maximum learning outcomes for students. Therefore, research is needed to obtain an illustration of whether or not there is a relationship between metacognitive skills, knowledge of ecosystem concepts, and critical thinking in MAN 1 Tangerang students.

Method

Correlation research was conducted to measure the level of relationship between the variables studied, which consisted of three variables, namely metacognitive skills (X1) and ecosystem concept knowledge (X2) as independent variables and critical thinking (Y) as the dependent variable. The research design is illustrated in Figure 1.

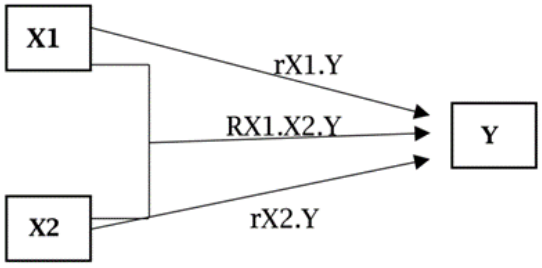

Figure 1. Constellation between Variables

The population and sample were selected using a multi-stage model. The first stage used purposive sampling from all SMAs and MAs in Tangerang Regency. The next step was using Cluster Random Sampling, which was selected by MAN 1 Tangerang, Class XI IPA, with 77 students as research respondents. The final stage used the Slovin formula to randomly obtain 65 class XI IPA-1 and XI IPA-2 students as the research sample.

The research was designed in three stages: preparation, implementation, and final. In the preparatory phase, the researcher compiled an essay on metacognitive skills and critical thinking skills using cognitive levels C4-C6, while essay questions for knowledge of ecosystem concepts with cognitive domains C2-C6. The instrument was further validated and assessed by experts.

At the implementation stage, tests were carried out on the instrument involving XI IPA 3 and XI IPA 4 students (except for those selected as research samples).

Preliminary data were collected from all students who were not included in the research sample but were still at the same level of education as the research sample, namely students in class XI IPA 3 and XI IPA 4. Then data were collected from the sample. In the research's final stage, data on each variable and interactions between variables were analyzed. After discussing the results of the analysis of each variable and the interactions between variables, conclusions are drawn about the correlation between metacognitive skills, ecosystem knowledge, and critical thinking.

The measurement instrument for each variable consists of 15 items, a metacognitive skills assessment rubric using Corebima (2009), critical thinking Zubaidah et al. (2015), and knowledge of ecosystem concepts; the three instruments are in the form of essay tests. Instrument

validity was carried out in two stages: validity testing by expert lecturers and empirical validity using Pearson Product Moment at a significance level of 0.05 and reliability testing using Cronbach's Alpha

Data analysis used in the research was a descriptive analysis technique with SPSS version 20 that included calculating a minimum score, maximum score, mean, and standard deviation of each variable. The prerequisite tests had a normality test using Kolmogorov-Smirnov (α = 0.05) and a homogeneity test using the Bartlett test (α = 0.05). Next, a multiple regression correlation test was conducted with alpha = 0.05, and the correlation test used Pearson Product Moment (α = 0.05) to determine the correlation level.

Results and Discussion

The results of the research conducted showed that the level of students' metacognitive skills was in very good and good criteria with a respective percentage of 20% and 80% as described in Table 1. This is in accordance with the statement made by Septiyani et al. (2020), which explained that the criteria for the level of students' metacognitive skills were grouped into five categories, namely very good, good, sufficient, lacking, and very lacking.

at a significance level of 0.05. The reliability test results of the item description test questions for all instruments stated that all instruments were reliable.

Meanwhile, the research results also show that there are six indicators of ecosystem concept knowledge and the percentage of achievement, namely the understanding-explaining indicator (C2) of 40%, the analyzing-connecting indicator (C4) of 20%, the analyzing-distinguishing indicator (C4) of 6 .67%, the understanding and conclusion indicator (C2) is 6.67%, the assessment detection indicator (C5) is 20%, and the hypothesis making indicator (C6) is 6.67% with a description according to the instructions in Table 2. This is in line with research conducted by Nabilah et al. (2018).

Furthermore, the results of this study also obtained eight aspects of critical thinking, namely classifying understanding of 20.00%, point of view analysis of 6.67%, evaluation finding relationships and patterns of 6.67%, interpretation finding relationships and patterns of 20.00. %, synthesis of explanations 6.67%, analysis considering various perspectives 13.33%, evaluations 20.00%, and decision-making based on evidence 6.67% with detailed explanations presented in Table 3.

Table 1. Percentage of average score for each metacognitive skill indicator

Indicator of Metacognitive Skills	Number of Question	Average	Standard Deviation	Percentage (%)
1. Planning	4	5.90	1.69	26.67
2. Information Mgmt Strategy	4	5.32	2.02	26.67
3. Supervision of Under-standing	4	5.37	1.76	26.67
4. Evaluation	3	6.01	1.62	20.00

(Source: Arikunto (2012) in Septiyani et al. (2020))

Table 2. Percentage of average score for each indicator of knowledge of ecosystem concept

	Indicator of Knowledge of Ecosystem Concepts (Cognitive Level)	Number of Question	Average Score	Standard Deviation	Percentage (%)
1.	Understanding– Explaining (C2) Relationship between ecosystem	6	3.34	0.98	40.00
2.	Analyzing– Connecting (C4) Impact of disturbance in the Inter-action in an ecosystem	3	3.66	0.82	20.00
3.	Analyzing – Differentiating (C4) Impact of disturbance in Inter action in an ecosystem	1	3.80	0.71	6.67
4.	Understanding and Concluding (C2) Impacts of the occurrence of eating and be eaten process	1	3.82	0.58	6.67
5.	Evaluating– Detecting (C5) Mechanisms of energy flow in an ecosystem	3	2.94	0.88	20.00
6.	Creating– Hypothesis (C6) Creating and designing a Biogeo-Chemical cycle	1	3.26	0.70	6.67

Source: (Purwanto (2012) cited as in Nabilah et al., 2018)

Table 3. Percentage of average score of each critical thinking aspect

Critical Thinking Aspect	Number of Question	Average Score	Standard Deviation	Percentage (%)
1. Classifying Understanding	3	4.50	1.16	20.00
2. Analysis Point of View	1	4.38	1.16	6.67
3. Evaluation Finding Relationships and Patterns	1	4.26	1.37	6.67
4. Interpretation Finding Relationships and Patterns	3	4.18	1.32	20.00
5. Explanation Synthesis	1	4.78	0.89	6.67
6. Analysis Consider Diverse Perspective	2	4.52	1.09	13.33
7. Evaluation – Evaluation	3	4.00	1.30	20.00
8. Decisions Making Based On Evidence	1	4.51	1.11	6.67

The prerequisite analysis test used in this study was the normality test carried out using the Kolmogorov-Smirnov (KS) test, while the homogeneity test was carried out using the Bartlett test at level = 0.05 using SPSS version 20. Based on the Kolmogorov-Smirnov (KS) test and the Bartlett test obtained normally distributed data and have the same homogeneity of variance.

Metacognitive skills do not contribute to the student's critical thinking (a correlation significant value was 0.106 > 0.05). this condition is different from Az-Zahra et al. (2021), which stated a positive relationship exists between metacognitive skills and understanding of motion system concepts and a positive relationship between metacognitive thinking skills and critical thinking and understanding of motion system concepts. The unformed relationship was likely due to each person that has different critical thinking skills attributable to various factors.

Critical thinking skills influenced include Language (Manalo & Sheppard, 2016), the instructional contexts which enabled a new situation, mastery of previous lecture materials, and student learning motivation (Slameto, 2017).

Other analysis results also state a positive relationship between ecosystem concept knowledge and students' critical thinking. So that a high score of ecosystem concept knowledge impacts the high value of critical thinking and vice versa. Knowledge of concepts can have an impact on students' critical thinking skills (Indrašienė et al., 2021; Wang et al., 2009). Although the contribution of knowledge to the understanding of critical thinking towards the surrounding environment (Gashan, 2015; Wilkin, 2017). Therefore, students tend to think critically in solving various environmental problems around them.

Based on the calculation and analysis of the 3rd hypothesis, the result of the significance F change was 0.000 < 0.05, which means that metacognitive skills (X1) and knowledge of ecosystem concepts (X2) simultaneously had a positive relationship with students' critical thinking (Y). The correlation coefficient was 0.539. This can be interpreted that the relationship being in the moderate category. The research indicates that metacognitive skills and knowledge of ecosystem concepts contributed 29.1% to the student's critical thinking and the rest was influenced by other factors excluded from the research.

Therefore, it can be stated that metacognitive skills and knowledge of ecosystem concepts were not the only factors that influence critical thinking. In the research, the metacognitive skills combined with the knowledge of ecosystem concepts have contributed to the student's critical thinking skills. The positive and simultaneous relationship formed between metacognitive skills and knowledge of ecosystem concepts and students' critical thinking indicated that when the score of the metacognitive skills and knowledge of ecosystem concepts increased, there was an increase in the students' critical thinking in the ecosystem content. This suggests that there was a strong relationship between metacognitive skills and critical thinking skills in improving learning outcomes (Akyol et al., 2010; Magno, 2010; Miharja et al., 2019).

Metacognition has a role in making learning succeed. Metacognition in high-order thinking skills consists of active control of the cognitive process in learning (Avhustiuk et al., 2021; Miharja et al., 2019). Such activities as planning to solve assignments, learning strategies to solve assignments, and evaluating; so, will affect their learning outcomes.

Critical thinking skills could assist someone in making an appropriate decision based on careful, systematic, and logical efforts and by considering various perspectives (Hidayati et al., 2020). Critical thinking involves metacognitive skills and through metacognitive skills, a thinker can be succeeded (Amin et al., 2020; Magno, 2010; Orion & Kali, 2018).

Stanton et al. (2011) presumed that metacognitive skill aspects could overcome difficulties in learning, whereas critical thinking provides reflective feedback as a part of the learning cycle to enhance students' skills; therefore, metacognitive skills and critical thinking contribute to improving cognitive learning outcomes from different perspectives. Good metacognitive skills will make students aware of how they should learn and help them in conditioning the learning process and finding their weaknesses and strengths as a reference in determining suitable learning strategies (Versteeg et al., 2021).

A student who has high critical thinking skills will be easier to develop his/her self-potential in every learning process, and it has a significant influence on his/her abilities to actualize his/her creativity potential at maximum and excellent. This will require teachers who can prepare maximally and thoroughly for every learning activity for their students. The preparation is in the form of better determination of learning process design according to competencies and indicators of achievement of the conveyed content.

Conclusion

Based on the research results, it can be concluded that there was a relationship between metacognitive skills and critical thinking, there was a positive relationship between knowledge of ecosystem concepts and critical thinking, and there was a positive relationship between metacognitive skills and knowledge of ecosystem concepts and critical thinking. A suggestion for other research is to measure metacognitive skills, knowledge of ecosystem concepts, and students' critical thinking skills. Teachers should be more thorough in preparing instruments of metacognitive skills by involving appropriate indicators and other factors that are excluded in the research. The research can be a reference regarding metacognitive skills, knowledge of ecosystem concepts, and critical thinking.

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