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## The analysis of metacognitive skills and creative thinking skills in STEM education at senior high school for biotechnology

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## The analysis of metacognitive skills and creative thinking skills in STEM education at senior high school for biotechnology

Kustiana<sup>1</sup>, Suratno<sup>1</sup>, and D Wahyuni<sup>1</sup>

<sup>1</sup>University of Jember, Kalimantan Street No.37, Krajan Timur, Sumbersari District, Jember Regency, East Java 68121

E-mail: [suratno.fkip@unej.ac.id](mailto:suratno.fkip@unej.ac.id)

**Abstract.** Biotechnology material will be more meaningful if done with practice. STEM education in improving student skills and is very suitable when collaborated with biotechnology materials. This study aims to analyze the metacognitive skills and creative thinking of students at STEM education in senior high school. The analysis in this paper uses descriptive analysis using mix method analysis. The sample in this study was 150 senior high school students. Data was collected using questionnaires and observations. Data collection techniques of creative thinking using observation with five assessment instrument that is inquisitive, imaginative, persistent, collaborative, and disciplined and metacognitive skills use the MAI (*Metacognitive Awareness Inventory*) questionnaire test. The result showed the metacognitive skills with STEM education increases in good categories with an average of 73,5. The highest students' creative thinking skills are persistent at 63,33% and the lowest was inquisitive 56,58%.

### 1. Introduction

Biology is an important subject in the curriculum. Biology is the most common subject required to enter fields of professional courses such as medicine, nursing, pharmacy, agriculture, biotechnology, etc. Biology can help students to understand the environment and expect students to develop awareness, positive attitudes towards the environment, scientific attitudes, and students' self -skills [1]. Biology is a special field that has subject matter ranging from small to complex, such as material about genes, cells, organelles, organisms, biomes, ecosystems, evolution, ecology, genetics and biotechnology [2]. The material in biotechnology is one of the innovative field consistently more popular, so students need to gain knowledge about technology and science from an early age so that for motivated to work and hone their skills [3]. Biotechnology is resulting from sains and technology, so curriculum development biotechnology materials have become important for secondary schools [4]. According to [5] Biotechnology is a field of science that develops from a scientific interest that is very important to be understood by students because of its potential impact on them and others. In honing students' skills in biology, especially biotechnology materials require learning that can help students improve their knowledge integrated with technology. Now, STEM education has developed to improving student skills and is very suitable if collaborated with biotechnology materials. STEM is an education that began to be seen by the government and educators in preparing students needed in the future. STEM is an education that integrates sains, technology, engineering and mathematics in



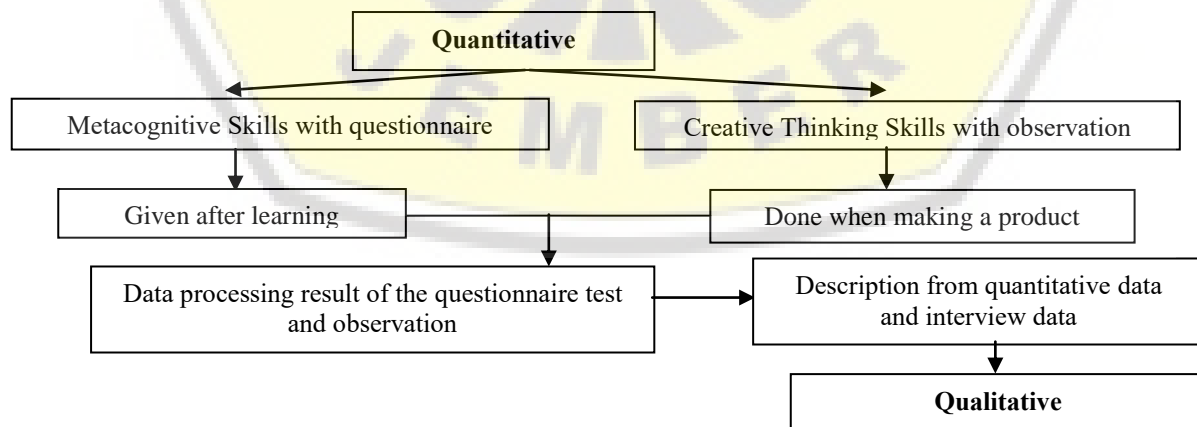
developing students' creative thinking skills including processes solving the problems [6]. STEM education applies an approach to problem-based learning and project-based learning that relies on direct and collaborative learning experiences as a method for solving problems [7]. STEM education is very suitable to be applied in the 2013 curriculum which applies scientific learning. Scientific learning is a learning approach that applying the scientific method, as well as integrating students in the thought process. Scientific learning not only focuses on observation or experiment but also on how to develop the knowledge and skills of students.

Individual skills that need to be improved in the 21st century are metacognitive skills and creative thinking. Metacognitive is an integration of higher-order thinking, which includes knowledge and metacognitive regulation through the reflection in maintaining behavior to solve problems in the learning process. Metacognitive is learning awareness that is built from a reflection on knowledge [8]. Metacognitive one type of thinking students about their cognitive processes [9]. According to [10] metacognitive awareness is in the thinking of a person be a strategy in learning. Metacognitive skills refer to the ability of individuals to regulate and control self-learning behavior [11]. Metacognitive skills can help students become independent learners, where independent learners are responsible for the progress of their learning [12].

According to [13] creative thinking is one of the skills needed in a society, so it is necessary to develop these skills as early as possible. These creative thinking skills are useful for the future, therefore they must have these skills. [14]. Based on [15] creativity can be assessed based on five habits of creative thinking namely Inquisitive, Imaginative, Persistent, Collaborative, and Disciplined. According to [16] creativity can make someone's life more enjoyable and valuable, the complex elements of society that require a person to be creative. According to [17] creative thinking can involve several compounds and the beginning of a problem then try to find a solution to the problem, then appear new ideas to solve the problem. High-level thinking skills need to be trained as early as possible to prepare valuable personalities in the future, so it is necessary to analyze the metacognitive skills and creative thinking at senior high school in STEM education for biotechnology.

**2. Method**

This article is included in the descriptive study because in this it only describes or illustrates the state of the environment or students' skills, namely the metacognitive skills and creative thinking skills of students with STEM education on biotechnology materials. Data analysis in this article used a mixed-method. The following are quantitative and qualitative methods carried out in this study can be seen in figure 1 modification from [18].



**Figure 1.** The Quantitative and Qualitative Method (Source: Modification from McKim, 2016)

Figure 1. shows the Quantitative data were obtained from observation sheets of creative thinking skills and a questionnaire about students' metacognitive skills following the MAI (*Metacognitive Awareness Inventor*) test. Qualitative data is shown by the descriptions of the metacognitive and creative thinking skills in STEM on biotechnology materials.

Metacognitive skills are measured using a questionnaire using the MAI (*Metacognitive Awareness Inventor*) test, based on [19] positive metacognitive skills are assessed by 3 indicators that shown in table 1.

**Table 1.** Indicators Metacognitive Awareness Inventory

Indicators	Activity
Planning skills	Making plans and setting goals
Predictive skills	Sorting strategies used and process information
Monitoring skills	Assessing the significance of the learning strategies used

(Source: Schraw, 1994)

The number of questions in the questionnaire is 5 questions for each skill, a maximum score of 15. The scores obtained will be converted into a 0-100 scale which will then be categorized using a rating scale modification from [20] is shown in table 2.

**Table 2.** Assessment Category of MAI Test

Category	Scale
Excellent	85 – 100
Very Good	68 – 84
Good	51 – 67
Medium	34 – 50
Low	17 – 33
Very Low	0 – 16

(Source: modification from Green, 2002)

Creative thinking skills are measured with an observation sheet using 5 indicators of creative thinking with 1 point of assessment of each indicator from [15].

**Table 3.** Indicators Creative Thinking Skills

Indicators	Activity
Inquisitive	Questioning
Imaginative	Hypothesizing
Persistent	Perseverance
Collaborative	Giving and receiving advice
Discipline	Making decisions

(Source: Lucas, 2016)

Assessment of creative thinking skills obtained from observations by calculating the average using the following formula:

$$K = \frac{r}{R} \times 100\%$$

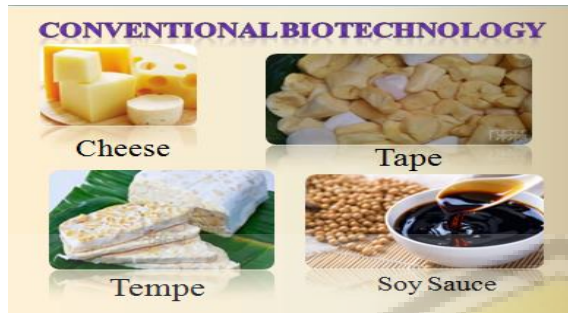
Information:

K: Average creative thinking skills (each indicator)

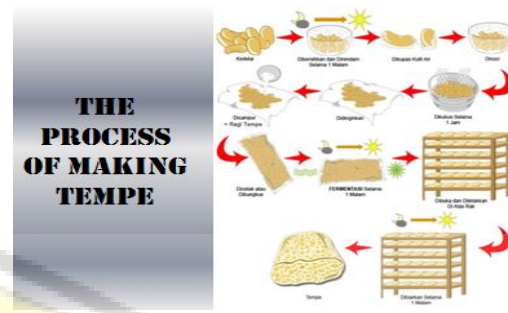
r: Average score

R: Maximum score

2.1 Student Task



**Figure 2.** Examples of conventional biotechnology results.



**Figure 3.** Example of the process of making tempe.

This study provides a project task to students the material biotechnology sub-conventional biotechnology materials by utilizing the surrounding environment which makes cheese and tape. Figure 2 shows examples of results from conventional biotechnology. Figure 3 shows an example of the process of making tempe which is one of the products or products from conventional biotechnology. This practice was conducted to analyze creative thinking skills students' accordingly the assessment indicators to be assessed are 5 indicators: inquisitive, imaginative, persistent, collaborative, and disciplined. If students can carry out tasks well then they will have a lot of new experience and knowledge. Biotechnology material is one of the materials that will be more meaningful if done with practice and produce a product.

3. Results

3.1 Analysis of Student Metacognitive Skills

Metacognitive skills were obtained from a questionnaire containing 15 questions with 3 categories of metacognitive skills. Analysis of metacognitive skills in STEM education for biotechnology lessons conducted on senior high school students in class XII, the data shown in table 4.

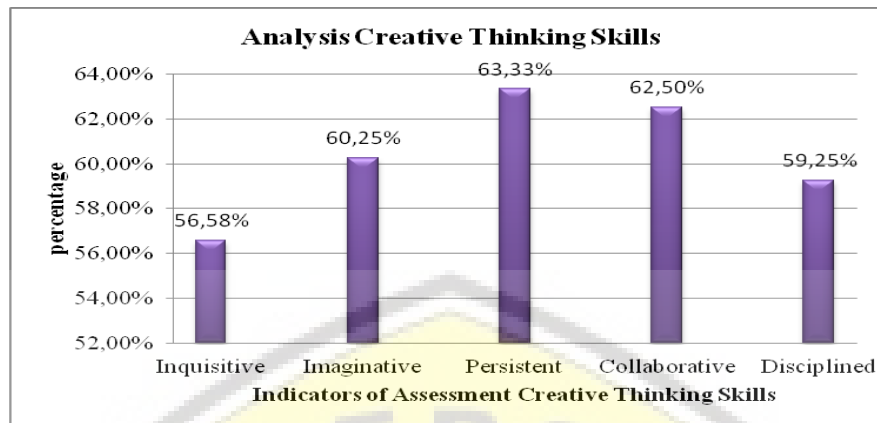
**Table 4.** Analysis of Metacognitive Skills Senior High School Students

	The number of students	Min	Max	Average	Category
Senior high school student metacognitive skills	150	50	100	73.5	Good

Table 4. shows the metacognitive skills in senior high school with STEM education biotechnology show the metacognitive skills that included in the category of *good* with an average of 73.5, with a minimum value of 50 and a maximum of 100.

3.2 Analysis of Students' Creative Thinking Skills

The material used in this study is biotechnology, where biotechnology is a material suitable if collaborated with STEM. Giving projects to students can analyze the creative thinking skills students in knowledge and technology. data for creative thinking skills students obtained from the observation sheet conducted by the teacher for students when giving projects in biotechnology materials. Analysis of creative thinking skills students in STEM education for biotechnology materials shown in figure 4 obtained:



**Figure 4.** Analysis of Creative Thinking Skills

Figure 4 describes the creative thinking skills students from the lowest indicators to the highest indicators. For the lowest indicators is inquisitive 56.58 %, disciplined 59,25 %, imaginative 60,25 %, Collaborative 62,50 %, and the highest is persistent 63,33 %.

#### 4. Discussion

Metacognitive skills in table 4 show the metacognitive skills student at senior high school in good category. Metacognitive skills are one of the most important skills in measuring student learning progress, this is in agreement with [21] which states that metacognitive skills are one of the most important skills in the future that can help students become independent and responsible for the progress of learning. According to [22] by analyzing metacognitive skills performed by students can assist students in exploring metacognitive skills and provide insights about cognitive awareness. Awareness of metacognitive is a derivative of higher-order thinking skills that aim to continue to maintain and develop self-metacognitive awareness [23]. In an opinion [24] states that by developing metacognition skills can be a challenge in STEM education, where students must concentrate on problem-solving based on theory. The application of STEM education in biotechnology greatly helps students to hone their creative and metacognitive thinking skills. This is similar to the opinion [25] which states that STEM education can improve students' high-level skills. With high-level skills, students can shape students to be creative, innovative and responsible for themselves.

From the results of research that have been done, the analysis of creative thinking skills in STEM education on biotechnology materials when conducting experiments in the production of biotechnology products, namely in processing milk into yogurt, cheese and Yakult, students shows their inquisitive in asking questions included in the low category with an average of 56.58%. Analysis from interviews with students shows that the lack is inquisitive because of the fear of the quality of questions so students are ashamed to express or ask questions or opinions. According to [26] a person can think creatively if he has more inquisitive and has a desire to find solutions to ideas that are found and then strengthened by the opinions expressed. In research conducted by [27] the lowest inquisitive due to students being less active, students often do not the homework, students are shy to ask questions in front of their friends because they are afraid the question is not right and students don't read often. With [28] questioning skills are an attitude that is very easily influenced, so need to pay attention and develop its influence factors to strengthen questioning skills students. Whereas the persistent indicators in the highest category when conducting experiments in the production of biotechnology products, namely in processing milk into yogurt, cheese and Yakult, showed student persistence of 63.33% the persistence of students in learning biotechnology is very visible during the product manufacturing process, according to [29] perseverance is a challenge inherent in creative action, which has the goal of being able to survive in the face of adversity. Perseverance in making

products is one of the positive challenges in guiding student creativity [30]. Because According to [31] problem-solving in making products is a form of creative skills that must be implemented based on student perseverance.

## 5. Conclusion

Metacognitive skills are one of thinking skills to maintain and develop learning abilities that aim to improve personal learning achievement, from the results of the analysis show that STEM education in biotechnology at senior high school can be concluded that the metacognitive skills of students are in the *good* category with an average grade of 73.5. Creative thinking skills are one of the skills needed in the current era of the industrial revolution, from this study show the creative thinking skills of students who are assessed by the observation sheet while making the product showed that the lowest indicator is inquisitive with an average score of 56.58%, the lack of questioning skills or inquisitive of students is caused by several factors namely lack self-confidence, lack of willingness to read, as well as students less active. For the highest indicator is persistent with an average score of 63.33% this is seen in the perseverance of students when completing their products.

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