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Critical thinking skills: Profile and mastering concepts of undergraduate students

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ABSTRACT

As one of the 21st-century skills, critical thinking (CT) is required for working in an interdisciplinary setting. Educators are expected to provide learning activities that enhance students' CT skills. Biology, particularly Cell Biology, is seen as challenging since the topics covered therein relate to those covered in the following semester. This research was conducted out as a preliminary study to improve the quality of the learning process, especially in the Cell Biology course. It aimed to identify students' CT skills in mastering concepts about Cell Membranes. This study enlisted the participation of 105 students from two universities. This research used an instrument test essay using the rubric CT skills. The findings revealed that undergraduate students' CT skills were classified as basic in mastering the concept of Cell Membrane.

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1. INTRODUCTION

The development of the times encourages transformation in education where everyone needs to have skills, and every learning process needs to develop 21st-century skills [1], [2]. In this era, critical thinking (CT) skills are the primary skills that need to be enhanced [3], [4]. As one of the fundamental 21-st century skills, CT skills are needed in life and also to be trained for every student [5]–[7], included undergraduate students. That is because critical thinking has a role in all aspects of life, moral development, social, mental, cognitive, and science [8].

Critical thinking skills are critical because they are used for decision making, forming opinions or arguing, and inferring something that can be accepted as truth [4]. Critical thinking entails more than just information acquisition; it can also include active learning, problem-solving, decision making and contains elements of reflective thinking, analysis, deduction, and induction [9]–[12]. However, some facts from all over the world, not least in Indonesia, showed that students' critical thinking skills are still at a low level [13]–[16]. To improve students' critical thinking skills, they need to practice continuously [4] through giving critical questions or solving contextual problems [17], [18]. As a direct consequence, students who have critical thinking skills are assumed to be better equipped for a future packed with demands and problems.

Critical thinking can be defined as a person's thought process in processing, analyzing, and evaluating information to solve problems and create new ideas [19]. Another view explains that critical thinking aims are reasoned and directed to solve problems, make decisions, formulate conclusions, and identify problems [20]. The essence of critical thinking is part of cognitive skills, including interpretation, analysis, inference, evaluation, explanation, and self-regulation [21].

In other words, CT is one of the higher-order thinking skills that enable a person to make decisions and take appropriate actions [11]. Therefore, CT skills are required in academics, the workplace, and society to achieve good academic performance and prosperous life in the future [22]. As part of higher order thinking (HOTs) and 21st-century skills, CT skills are essential, especially in education, because one of the ultimate goals of education is to produce critical thinkers [23], [24]. With today's world's quick interchange of information, critical thinking becomes even more crucial [25].

Based on the research described, we assume that CT skills are essential skills that students should have. The students need to practice their critical thinking skills to compete in the work environment and face the challenges of industrial revolution 4.0, including society 5.0. Thus, improving students' CT skills are necessary not just at the level of primary and secondary school but also in higher education. Critical thinking skills are also closely related to biology content and learning [26]–[30]. Chapman [31] noted that biology learning often has a conventional pattern of memorization strategies and feedback through exams. Addy *et al*. [23] also highlight that biology is more than just factual knowledge. Nevertheless, it requires a critical thinking process inside of mastering biology. Furthermore, developing critical thinking skills needed a basic understanding of the primary branches of science.

As we know that cell biology is part of the study of biology that deals with understanding concepts and student learning abilities [32], [33]. However, in reality, topics about cell biology are often considered problematic and thus low impact on students' CT skills or are at the level of low order thinking [33], [34]. Learning about cell biology is often found in several misconceptions [35]–[37]. Saputri *et al*. [15] conducted students' interviews explained that cell concepts are complex content to understand. Besides that, their national exam (UN) result also shows that mastering cell concepts is still low rather than other content. This is presumed that the learning process has not been optimal, significantly to enhance students' thinking skills. Whereas the topic of cell is a fundamental concept to conceive biology next level, and it relates with future trends in the 21st century, and cell concepts also become a necessity for application in everyday life [38].

Based on the description, learning about cells is material biology that has a lot to do with future trends in the 21st century and has become a critical necessity for everyday life. This study is preliminary research that focused on students' CT skills of the concepts about structure and function of cell membranes. In addition, the study's findings will become the basis for developing a product to evaluate biology learning, especially cell biology content.

2. RESEARCH METHOD

This was a descriptive performed between December 2019 and February 2020 in two different universities (universities A and B). A total of 107 students participated in this research. These can be divided into 105 students who filled the instrument test critical thinking skills with essay form, and two lecturers were interviewed about cell and molecular biology that ongoing lesson. The entire subject of research consists of 31 male students, with the rest 74 female students. Subjects were determined by purposive sampling. Using purposive sampling is that material cell and molecular biology are taught in the 4th level semester, and not all departments of biology education combine that material lesson. Sometimes both of them are separated into lessons cell biology and lesson molecular biology.

The instrument used refers to the rubric of critical thinking developed by Stephen F. Austin (SFA) University and modified by the Association of American Colleges and Universities [39] according to educational needs at the university level, where the rubric describes the criteria of each indicator of critical thinking as shown in Table 1. In the SFA rubric, critical thinking is a mindset that involves a thorough examination of situations, ideas, artifacts, and events before accepting or creating an opinion or conclusion. SFA rubric critical thinking contains measured indicators, including: i) Identification and explanation of issues; ii) Collection of information; iii) Recognition of context and assumptions; iv) Evaluation and synthesis of information; v) Conclusions and related outcomes.

The instrument test is formed essay, consist of the topic of structure and function of cell membrane. The topic of structure and function of the cell membrane was chosen because it is one of the base contents for the cell and molecular biology course and other core biology courses. The scope of the structure and function of the cell membrane to examine contains an understanding of the transport of substances through the cell membrane, cell membrane functions, and differences in the structure of cell membrane and cell wall. The scope of the content is a foundation for creating up to five questions integrated with the SFA rubric critical thinking indicators.

Data were analyzed in this study is used a descriptive analysis method, which is a percentage and description of the results from the data source. The data result from the scoring of the test of students' answers to items that denoted their CT skills. Quantitative data were analyzed using Microsoft Excel 2016 software analysis ToolPak, producing outputs such as graphs and item summary statistics. After reducing the

data, students' answers were evaluated by using qualitative analysis. This study's data presentations are the result of analyzing primary data to describe students' CT skills of cell membrane structure and function.

Table 1. Critical thinking criteria by SFA University [39]

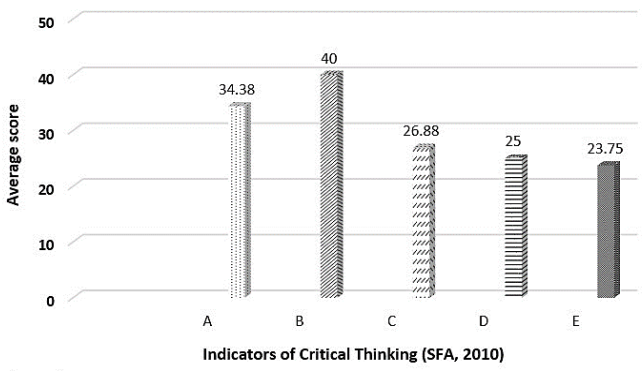
Score SFA	Level/Category	Score conversion
0	Low/Unacceptable	0-19.99
1	Basic/Beginning	20-39.99
2	Intermediate/Developing	40-59.99
3	Skilled/Accomplished	60-79.99
4	High (Very skilled)/Capstone	80-100

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. The profile of students' critical thinking skills

Students' CT skills on the topic structure and function of cell membranes are still classified as a basic category known as "beginning" with a score of 1 ($\bar{x}$=30). From the five SFA rubric critical thinking indicators, the only indicator Collection of information that is in the "intermediate" category ($\bar{x}$=40). For indicators Identification and explanation of issues ($\bar{x}$=34.38); Recognition context and assumptions ($\bar{x}$=26.88); Evaluation and synthesis of information ($\bar{x}$=25); are in the "basic" category. Likewise, indicators Conclusions and related outcomes is at the "basic" level ($\bar{x}$=23.75). Figure 1 depicts a comparison diagram of students' CT skills as seen through each of the indicators.

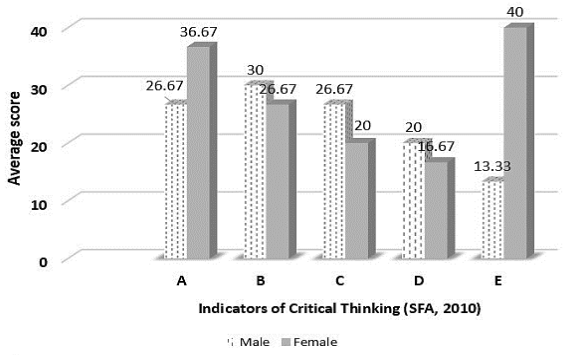


Information:
A (Identification and explanation of issues)
B (Collection of information)
C (Recognition context and assumptions)
D (Evaluation and synthesis information)
E (Conclusion and related outcomes)

Figure 1. Profile of students' critical thinking skills

3.1.2. Students' critical thinking skills based on gender

The results of the acquisition of CT skills of students, when viewed from gender differences, shows that female students have some higher average values ($\bar{x}$=30.15) compared to male students ($\bar{x}$=29.17). If it is seen, each aspect shows differences in average values, even if it is not significant. The CT skills of female students have better than male students in the aspects of Identification and explanation of issues ($\bar{x}$=36.67) and Conclusion and related outcomes ($\bar{x}$=40). Meanwhile, male students' CT skills have better than female students in the aspects of Collection of information ($\bar{x}$=30), Recognition context and assumption ($\bar{x}$=26.67), and Evaluation and synthesis of information ($\bar{x}$=20). Figure 2 depicts the findings of an analysis of male and female students' CT skills.

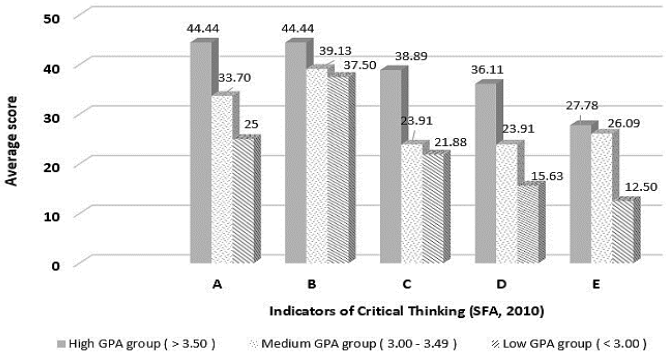


Information:
A (Identification and explanation of issues)
B (Collection of information)
C (Recognition context and assumptions)
D (Evaluation and synthesis information)
E (Conclusion and related outcomes)

Figure 2. Students' critical thinking skill-based on gender

3.1.3. Students' critical thinking based on GPA score

Students' critical thinking skills showed the differences based on grade point average (GPA) scores. The GPA scores are categorized into 3 groups, High (>3.50); Medium (3.00-3.49); and Low (<3.00). The group of students with a high GPA score has students' critical thinking skills categorized in "intermediate" level ($\bar{x}$=40). While the GPA score in the medium ($\bar{x}$=30.63) and low ($\bar{x}$=22.50) group has students' thinking skills categorized in "basic" level. GPA scores also indicate a student's CT skills. Students in with high GPAs group have excellent critical thinking skills scores in all aspects. Similarly, a student in with medium and low GPAs group have lower than high GPAs group in all aspects' critical thinking. A summary of the students' CT skills analysis based on GPA score groups is shown in Figure 3.



Information:
A (Identification and explanation of issues)
B (Collection of information)
C (Recognition context and assumptions)
D (Evaluation and synthesis information)
E (Conclusion and related outcomes)

Figure 3. Students' critical thinking skills based on the GPA score

3.2. Discussion

Critical thinking skills in students have become a critical instructional focus. It has to do with a perceived need to deal with fast information in this day of globalization. However, these CT skills are not inborn nor naturally developed but should be trained continuously to students. As we know, students' CT skills can be enhanced by using a contextual approach to directing students into realistic thinking based on their real-life circumstances. Critical thinking is necessary to students' success in college and the workplace [40]. Using the SFA rubric critical thinking skills, we could discover students' critical thinking skills from their answers. The quantitative analysis results showed that students' CT skills were relatively low. It impacted to mastering the concept of cell membrane. Figure 1 shows that each indicator of students' CT skills has different results even though categorized low-level CT skills. This is in line with the opinion of Ennis [11], in which each indicator showed that different results. The critical thinking skills aspect will undoubtedly show that different results.

Based on the qualitative analysis of students' answers, the results showed that students had provided information about cell membrane and cell wall are so well, but they have not been able to analyze and synthesize differences between cell membrane and cell walls as structurally. They only answer the characteristics of cell membrane and cell wall in common, have not been seen analyzing the structure of its composition like what and how. Demir [9] stated that critical thinking is about presenting information and

involves solving problems and utilizing information. Hall and Kidman [41] also convey that enhancing students' critical thinking and contextual learning can make the atmosphere centered on student learning.

Students are trained to be critical thinkers when contextual learning is applied. We argue that critical thinking is indeed an active process that involves metacognitive thinking about thinking itself and that, as a result, students become more critical and creative in their thinking. According to Hasrudin [42], learn biology to memorize and understand the subject matter. They will strive to integrate the concepts they have learned so far, and then they will be able to construct knowledge based on their own experiences [43].

In this study, CT skills are also described by Gender, and it has differences between male and female students. Figure 2 showed that female students have higher average critical thinking scores than male students. This is in line with the opinion by Behar-Horenstein and Niu [17] that critical thinking skills between men and women are different. Although women's critical thinking skills are better than men's, gender differences in critical thinking skills provide knowledge to higher education practitioners to facilitate the development of students' CT skills because these differences are found in the process of critical thinking [44]. Bagheri and Ghanizadeh [45] add that women have learned to be as good critical thinkers as males to solve everyday challenges and use their critical thinking abilities regardless of their gender.

According to Figure 2, indicators C (Recognition context and assumptions) and D (Evaluation and synthesis of information) showed no difference in the average score of CT skills between male and female students. This is in line with the opinion by Rahman [46] that critical thinking skills between men and women did not show a significant difference. In line with this, [47], [48] there are no differences in CT skills between males and females. Yousefi and Mohammadi [49] also convey that gender differences do not significantly differ in the understanding aspect. Meanwhile, indicator B (Collection of information), findings different results: male students' critical thinking skills have a higher score. Previous researchers [50], [51] state that men are influenced by various learning experiences and thought processes so that it is easier to gather information. Men have better visual and numerical performance, while women generally have better verbal skills.

Critical thinking skills are also related to students' cognitive abilities as measured through tests of understanding learning outcomes. The study results show that students with high GPA scores have good CT skills (middle category). Critical thinking skills are related to one's academics [17], [52], [53]. Although GPA is connected to critical thinking abilities, the academic performance index has a weak correlation. Therefore students with high GPA are not assured of having high critical thinking skills, or conversely [54]. However, students can develop their interpretation, which leads to critical thinking. Students' cognitive abilities can be improved with a learning method that engages them directly (student-centered). Whereas a person's critical thinking skills are limited, it will not exclude them from being trained. The effort to practice critical thinking is to be acclimated into daily life [55]. Giving a simple example about how useful cells are for our body is one of the ways to make students' understanding of cell concepts easy.

According to the results of interviews with lecturers, they also convey that the existence of cell has not facilitated students and molecular biology textbooks in Bahasa (Indonesian language) or textbooks are made by lecturers. It certainly complicates students' understanding of cell and molecular biology. By the result of observation class, another reason students' critical thinking is low level is that some lecturers have not directly involved students in learning or trained students' CT skills in the learning activities. To enhance students' critical thinking skills, various learning strategies such as inquiry, group discussions, cooperative learning, or problem-based learning can be used. Lecturers should have a written lesson plan with various methods, so a good lesson plan and textbooks can improve students' critical thinking skills. In line with that, empowering critical thinking may be achieved through active learning, which involves students directly in the learning process and preparing the subject before learning starts by using the textbooks [56].

Based on the research results described, this research is helpful for lecturers to change their perspective in teaching biological concepts that are abstract, especially content about cells or molecular. The lecturers need to understand that content about cells or molecular is challenging to learn by students. Therefore, as educators, lecturers need to design a learning resource in the form of textbooks that are easy-to-understand language, and the textbooks also contain critical questions so the students can learn to analyze, evaluate, or synthesize information. That way, another course with abstract content and students' critical thinking skills can be resolved more or less.

4. CONCLUSION

This study is preliminary research that explored the level of critical thinking skills of undergraduate biology education students in the subject of cell and molecular biology. This study revealed that students' critical thinking skills in the topic "Structure and function of cell membranes" are categorized at the primary level. Most students have not been able to make "Conclusions and related results". They show inconsistent

what they know, and their answers are oversimplified that there are no implications. Only the "Collection of information" indicator is categorized in the intermediate level. On this indicator, students' critical thinking skills were in the developing step. They tried to answer with all of the information they knew even though they had not been able to analyze and synthesize their answers. Furthermore, students' critical thinking skills have no significant relation to their gender and GPA scores despite the differences in critical thinking scores in each indicator.

In line with the results, some ways are needed to improve students' critical thinking skills. Theoretically, this research implies that critical thinking is more than just forming opinions or argues. Moreover, it is as a part of cognitive skill which includes several aspects including identification and explanation of issues, collection of information, recognition context and assumptions, evaluation and synthesis of information, and the last one is conclusions and related outcomes. Therefore, critical thinking skills must be trained continuously in the learning process. Practically, this conclusion implies facilitating students with textbooks containing critical questions of the topics studied. The textbook's design needs to be integrated with critical questions related to cell and molecular biology concepts. In addition, textbooks are required to use language (Indonesia) that students easily understand. The textbooks can also have added aspects of metacognition, such as self-regulation for student learning, which is part of critical thinking. The integration of critical thinking and metacognition aspects in one textbook will be expected to synergize and ultimately improve students' critical thinking skills. Furthermore, the textbooks can be used by lecturers and students to facilitate their learning to improve students' critical thinking skills, especially in cell and molecular biology courses, or can be developed in other courses.

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