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Research Article

Critical thinking skills of natural science undergraduate students on biology subject: Gender perspective

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ABSTRACT

One of the most important skills needed to face the 21st-century challenges is critical thinking. Gender differences are considered to contribute to the critical thinking skills. The objective of this study was to determine students' critical thinking skills based on gender. This quantitative research involved 57 students of the Natural Sciences Education Study Program, Universitas Hasyim Asy'ari. The instrument employed was critical thinking skills test. The data was analyzed using independent samples t-test. The results showed that the average scores of critical thinking skills of male and female students were 2.60 and 2.99 respectively. In addition, there was significant difference of students' critical thinking skills between male and female [t (55) = 2.065, p = 0.044]. In conclusion, female students tend to have the higher critical thinking skills than the male.

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INTRODUCTION

During the 21st century, the world has experienced very rapid changes in every aspects of life. They are economical, transportation, technology, communication, information, and many others. According to Zubaidah (2016) that the changes demand people to master various skills. The skills should be relevant to four pillars of life, including learning to know, learning to do, learning to be, and learning to live together. Therefore, education is expected to prepare students to acquire various skills so that they can achieve success in life. According to Bensley and Spero, (2014), one of the skills needed to face the challenges of the 21st century is critical thinking.

Critical thinking is a complex mental activity that requires high-level thinking skills in overcoming problems, making decisions and drawing conclusions (Boa, Wattanatorn, & Tagong, 2018; Saavedra & Saavedra, 2011; Souf & See, 2019; Tiruneh, Gu, Cock, & Elen, 2018). Furthermore, identify critical thinking as a way to establish a high level of thinking that is limited to one's thoughts, rather a strong desire to monitor, assess and rearrange one's dreams (Azin & Tabrizi, 2016; Butler, Pentoney, & Bong, 2017; Yue, Zhang, Zhang, & Jin, 2017). Critical thinking is reasonable, and reflective thinking focused on deciding what to believe or do (Chen, 2017; Gilboy, Kane, & Everson, 2004; Wheeler & Collins, 2003).

According to Cone, Bond, and Pierson, (2013) conveys the definition of critical thinking including the concept of information analysis, the application of strategies to decide things, the readiness to consider ideas, use logical questions, make inferences, assess evidence, test conclusions, make accurate decisions and analyze assumptions. According to Fahim and Ahmadian, (2012) stated that critical thinking was a higher-order thinking skill, and was known to play a role in the moral, social, mental, cognitive, and science development. According to

Gloudemans, Schalk, & Reynaert, (2013) explained that the concept of critical thinking involves cognitive skills and affective perspective. Furthermore, critical thinking requires one's efforts to gather, interpret, analyze, and estimate information to obtain correct and valid conclusions. Critical thinking can also involve logical reasoning and the ability to separate facts from opinions, examine information critically with evidence before accepting or rejecting ideas and questions related to the problem at hand.

Critical thinking is necessary for problem-solving, including problem identification activities, problem analysis, reasoning presentation, evidence evaluation, and decision making. In critical thinking, there are high-thinking activities for decision making with full consideration, which involve various resolution strategies accompanied by sources and logical reasons (Abbasi & Izadpanah, 2018; Alfonso, 2015). When a person has good critical thinking, that person will always be curious, have good reasoning, open-minded, honestly acknowledge mistakes, and careful in making judgments which enable him/her to solve problems, form conclusions, calculate all possibilities, and make decisions.

The student's critical thinking skill should be improved since it is essential for student's development. According to Zubaidah et al (2015) stated that critical thinking skills could be used by students to assess various opinions that arise so the student's can decide which ideas are scientific. A similar statement was also explained by Alfonso (2015) that by having critical thinking skills, students could improve their argument understanding, express their perspectives, and give essential consideration to the topic. According to the opinions of these experts, it can be deduced that undergraduate students who have excellent critical thinking skills will be able to assess the problem of the questions provided, accompanied by logical arguments and evidence.

The critical thinking skills of each student's is different, one of which can be influenced by academic abilities. According to Heijltjes, Gog, Leppink, and Paas (2014) based on their results of research on undergraduate students of International Islamic University Malaysia (IIUM), said that different academic abilities affect different critical thinking skills. Through the results of his research, explained that reading skills influence critical thinking skills. Furthermore, to improve critical thinking skills, student's need to be often trained to read, write, and speak. Communication skills influence critical thinking skills. Moreover, analyzed that the undergraduate student's who show critical thinking when having communication in the classroom tend to share their ideas, showing the interrelationship among their ideas, and producing a higher level of critical thinking.

Various studies on critical thinking skills in male and female have been carried out with nursing student's in Australia (Hunter, Pitt, Croce, & Roche, 2014), southeastern United States (Jones & Morris, 2007), Malaysia (Ludin, 2018), Jordan (Rababa & Masha'al, 2020), as well as with the subject of doctor of pharmacy student's in California (Peeters & Boddu, 2016). In Indonesia also conducted research on critical thinking skills in male and female in mathematics with junior high school subjects in Banda Aceh (Mawaddah, Ahmad, & Duskri, 2018), biology lessons with senior high school subjects in Banjarmasin (Ramdiah & Corebima, 2014). On the other hand, research that focuses their studies on biology concepts for natural science students has never been done.

Studies like this will help educators find out how to effectively instill the ability of critical thinking skills for male and female students, especially in biology. This study also provides information on why critical thinking skills in men and women have differences so that students in Indonesia can optimize their critical thinking skills according to their abilities.

Basic biology course is a prerequisite course during the even semester (second semester) at the Natural Sciences study program, Faculty of Education, Hasyim Asy'ari University Tebuireng Jombang (UNHASY). Science students in the early semester are expected to be able to master the basic concepts of biology as a reference to make it easier to understand the concept of biology as a whole. Besides, students are expected to have critical thinking about biology concepts so that they can apply the concepts obtained to overcome various problems in daily life, especially those related to biology. According to Ruder and Martich (2015) critical thinking will encourage students to have an in-depth perception of the material theory, knowledge, skills, and critical disposition so that it will ultimately affect the improvement of their academic abilities.

In the learning process on basic biology course, male and female students have different perspectives and thinking ability which can be seen during lecturing. This study was conducted to reveal the differences in the critical thinking skills of male and female students at the Natural Science Study Program of Hasyim Asy'ari University at Tebuireng Jombang (UNHASY) in the biology subject. This research is different from the previous studies which viewed critical thinking based on gender. This research is necessary because research that illustrates student's critical thinking skills of the UNHASY Science Study Program and the differences in critical thinking skills between male and female students has never been done before.

METHOD

This study is a survey research with a quantitative approach. This research was conducted in B building UNHASY, Irian Jaya Street No. 55 Tebuireng, Jombang, East Java, during the even semester 2018/2019. The subjects of this research were 57 student's of the UNHASY Natural Science Education Study Program who had taken the basic biology course, consisting of 11 male and 46 female students. The instrument of this research is a test of critical thinking skills in the form of a description questions/essay test, which consists of 6 questions. Biology topics in instruments include the respiratory system, environmental pollution, food additives, immune system, movement system, and sensory system.

Question number 1 is about the topic of the respiratory system (smoking habit), question number 2 is about environmental pollution (waste processing), question number 3 is about consuming food additives, question number 4 is about the immune system (vaccinations for infants), question number 5 is about movement system

(the effect of sitting position on the bone shape), and question number 6 is about the sensory system (habits that affect eye health).

The preparation of question instruments refers to pre-research questions of critical thinking skills of Prof. Dr. Siti Zubaidah, M.Pd (lecturer of the biology department of the State University of Malang), and also as a validator of this research instrument. The advice of the validator determines the number and topic of questions. The measurement of critical thinking skills refers to the assessment rubric that was adapted by Zubaidah et al (2015) from illinois critical thinking essay test and guidelines for scoring illinois critical thinking essay test as shown in Table 1. The score achievement indicator of the student's critical thinking skills ranged in 0-5, as shown in Table 2.

Table 1. Assessment rubric of critical thinking skills

Score/Point	Descriptor
5	• All concepts are correct, clear, and specific. • All explanations are correct, clear, and specific, supported with strong, correct, and clear arguments. • The flow of thought is good. All concepts are interrelated and integrated. • The grammar is good and correct. • All aspects are obvious, the evidence is good and balanced.
4	• Most of the concepts are correct and clear but less specific. • Most of the explanations are correct and clear but less specific. • The flow of thought is good. Most of the concepts are interrelated and integrated. • The grammar is good and correct or there are small mistakes. • All aspects are obvious but not balanced yet.
3	• The concepts are unfocused or too many or uncertain. • The explanation is unsupportive. • The flow of thought is not quite good and the concepts are not interrelated • The grammar is good but the sentence is incomplete. • Few aspects seem correct.
2	• The concepts are unfocused or too many or uncertain • The explanation is unsupportive • The flow of thought is not quite good and the concepts are not interrelated • The grammar is good but the sentence is incomplete • Few aspects seem correct
1	• All concepts are incorrect or insufficient • The reasons are incorrect • The flow of thought is poor • The grammar is poor • All aspects are insufficient
0	• There is no answer or the answer is wrong

Table 2. Range of score achievement indicator of critical thinking skills

Indicator range	The criterion of critical thinking skills
0-2	Not yet increased or underdeveloped
3-5	Well developed

Then, the prerequisite test is performed on the students' critical thinking skills score data through the Kolmogorov-Smirnov One-Sample normality test and the Levenes Test for Equality of Variances homogeneity test to find out whether the critical thinking skill score data is normally distributed and homogeneous or not. After the prerequisite tests, the data from the test of critical thinking skills were analyzed by using quantitative descriptive analysis, which employed the Independent sample t-test to explain the differences in the critical thinking skills of male and female students.

RESULTS AND DISCUSSION

The result of the normality test of data scores students' critical thinking skills is shown in Table 3. Based on Table 3 it shows the score of students is normally distributed with a significance value for male students of 0.654 and female students of 0.793. The average score of critical thinking skills of male students is 2.60, and the average score of critical thinking skills of female students is 2.99, both of which are included in the criteria of not yet increased or underdeveloped.

Homogeneity test results and t-test results of critical thinking skills score data are shown in Table 4. Based on Table 4 it is known that the homogeneity test results show a significance value $\geq$ 0.05 that is equal to 0.545 so that the data is homogeneously distributed. T-test results show that the significance value $\leq$ 0.05 is equal to 0.044; it shows that there are differences in students' critical thinking skills based on gender. Female students get a score of critical thinking skills higher than male.

The results of data analysis showed that the average score of critical thinking skills of Natural Science Study Program UNHASY student's in the 2.92 indicator range with the criteria of not yet increased or underdeveloped. Out of 57 student's, 29 student's (50.88%) have critical thinking skills with well-developed criteria, and 28 student's (49.12%) have critical thinking skills with not yet increased or underdeveloped criteria. The percentage

of the student's critical thinking skills scores is shown in Figure 1.

Table 3. Result of normality test with one-sample Kolmogorov-Smirnov test of students critical thinking skills score

		Female	Male
N		46	11
Normal Parameters[a,b]	Mean	2.9937	2.6027
	Std. Deviation	.55622	.59803
Most Extreme Differences	Absolute	.096	.221
	Positive	.079	.221
	Negative	-.096	-.139
Kolmogorov-Smirnov Z		.650	.734
Asymp. Sig. (2-tailed)		.793	.654

a. Test distribution is Normal.
b. Calculated from data.

Table 4. The t-test results of student's critical thinking skills score data

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
Critical Thinking	Equal variances assumed	.371	.545	-2.065	55	.044	-.39097	.18931	-.77036	-.01157
	Equal variances not assumed			-1.974	14.428	.068	-.39097	.19809	-.81464	.03271

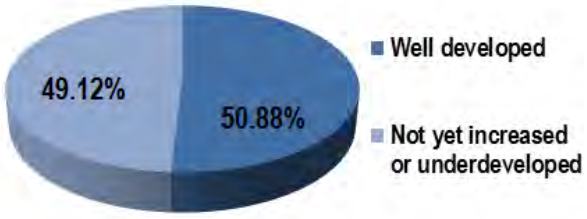

Figure 1. Chart of the percentage of students critical thinking skills score overall

The average score of critical thinking skills of male students is 2.60, and the average score of critical thinking skills of female students is 2.99, both of which are included in the criteria of not yet increased or underdeveloped. Next, the average score of students' critical thinking skills based on gender is summarized in the chart in Figure 2.

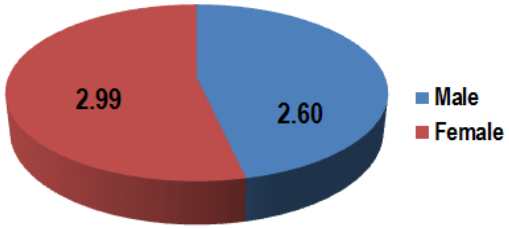

Figure 2. The average score of students critical thinking skills based on gender

The results of data analysis based on Table 4 show that there are differences in the scores of critical thinking skills between male and female students. Through the written test answers of students, it can find out the students' critical thinking skills. Someone who thinks critically can show their thoughts well through the use of the right language when speaking or writing. These are the sample of student answers toward questions number one and two of the research instrument (Table 5).

Related to the students' answers, they have almost the same result due to the discrepancies in critical thinking skills among students (Boa et al., 2018; Lloyd & Bahr, 2010; Mawaddah et al., 2018). Furthermore, from the results of research conducted by Butler et al., (2017), it presents that women's critical thinking skills are better

than men's. According to Fahim & Bagheri, (2012) have proven that gender differences contribute to critical thinking scores.

Table 5. Sample of student answers toward questions number one and two of the research instrument

No	Question	Answer
1	Smoking is a habit that many Indonesian people do. Although the dangers of smoking are known to both themselves and others around them, they still do so for a variety of reasons. They smoke in various places, even in public places. Do you think they need to be given a special place to smoke? What do you think about that? Explain your reasons and provide solutions to these problems!	1. These are the students' answers for question number 1 which belong to were not increased or underdeveloped critical thinking skills criteria: a. FDs answer (female): I think we don't need to provide smoking areas since there are numerous smokers in Indonesia. If we provide smoking areas, then how many areas should we build? However, if we must provide the smoking areas, I think we need to build them in certain places, especially public areas b. GRs answer (male): It's necessary to provide the smoking area because not all smokers have awareness about the people around them. 2. These are the students' answers for question number 1 which belong to well-developed critical thinking skills criteria: a. NFs answer (female): We need to provide smoking areas because cigarette smoke can annoy other people who are nonsmokers. By providing smoking areas, at least there is no one complaining about cigarette smoke. The smoke can make people who are allergic to it cough. These smoking areas can indirectly minimize the effect of the smoke on passive smokers who can get sick or die. As we know, passive smokers get more harmful effects than active smokers. b. AGBs answer (male): Smoking areas are necessary because the smoke harms both the smokers and the nonsmokers. Even according to researches, passive smokers have a higher risk than active smokers. Because of this reason, smoking areas are needed, especially in public facilities, so that the nonsmokers won't be exposed by the negative effect of the smoke.
2	Nowadays, we can find a lot of food, which is an added coloring and flavor enhancer, to attract consumers' attention. Some people think that this food is consumable. What do you think about this kind of food? Please explain your answer!	1. These are the students' answers for question number 1, which belong to not yet increased or underdeveloped critical thinking skills criteria. a. NPPMs answer (female): Food which contains artificial food additive is inconsumable because it can cause health problem such as tumors, cancers, etc. b. ASAs answer (male): If the flavor enhancer and coloring contain harmful substances, it's better for us not to consume that kind of food. 2. These are the students' answers for question number 2 which belong to well-developed critical thinking skills criteria. a. AFKs answer (female): The food which contains food colorings and flavor enhancers is more appealing than the ones without them. Nevertheless, artificial food additives contain high-risk chemical substances that endanger humans' health. We may use food additives moderately or apply the correct dose. However, we can choose natural food additives that are safe for our health. b. Sas answer (male): I think the food which is added with artificial coloring and flavor enhancer is not consumable because that food is harmful for our health. We must use natural food coloring and flavor enhancers instead.

Furthermore, female student's show better performance in reading literacy, and meanwhile, male student's show better performance in math and science subjects. Related to that, through the results of his research Gloudemans et al (2013) reported that female students have higher learning achievement in science compared to male student's. According to Heijltjes et al (2014) stated that relating to the brain's anatomy of males and females, men have more developed brains and have more complex abilities in planning, memorizing direction, abstraction, and visualization. A male has a brain with the area of cortex working on spatial functions more so that the ability of a man to produce and process words becomes less. Meanwhile, the female has a corpus callosum, which is four times larger than man, so that a man cannot focus on more works at the same time.

Male and female have differences in problem-solving. The results of research conducted by Istiyono et al (2019) show that female student's can solve problems better than male student's. In line with the findings of Jones and Morris, (2007) that female student's complete complex tasks such as problem-solving better than male student's. The same resource that female student's tend to do better tasks that require knowledge and skills in problem-solving, such as mathematics. Based on the explanations, that female students were more careful and through to re-examine what they had done and had better debating skills than males. Female students tend to ask questions more precisely and credibly compared to male students, which means that female students have better critical thinking skills than male students. Briefly, gender impacts students' critical thinking skills.

According to Azin and Tabrizi (2016) findings showed there is no significant difference between male and female in critical thinking, male and female students will have different ways to explore their critical thinking skills when they are faced with a particular problem. Besides, according to Peeters and Boddu, (2016) the age difference between students can cause variations in critical thinking. According to Ramdiah and Corebima (2014) said that the age difference affects the growth and development of a person's level of thinking maturity, including thinking in solving tasks or problems. Furthermore, they explained that differences in biological growth that occur in terms of gender cause significant differences between students' critical thinking skills. Concerned with that, according to Ruder and Martich, (2015) evidence of gender differences in problem-solving tasks, where women lagged behind boys in developing logical thinking skills. The same resource also explained that the difference began to be seen around the age of 11 years. A moderate correlation has been found between a positive attitude towards science and higher achievement in science. Moreover, according to Souf & See, (2019) it seems that the issue of why boys perform better than girls in science or why women do not choose science as a career is complex and very controversial.

Critical thinking skills of students need to be developed to achieve well-developed criteria. It is essential to provide activities to encourage critical thinking in the classroom and introduce active reading, free discussion, analytic writing, dynamic assessment as techniques that contribute to empowering critical thinking (Carter, Creedy, & Sidebotham, 2016; Fahim & Bagheri, 2012; Kawashima & Petrini, 2004). Besides that, it is also suggested the application of problem-based learning, active learning, and constructivist approaches to facilitate critical thinking skills, meaningful and long-lasting learning (Lauder & James, 2001; Pieterse, Lawrence, & Nel, 2016; Tiruneh et al., 2018; Yue et al., 2017). In learning science especially Biology, critical thinking skills can be applied in cooperative learning type cooperative script and think pair share (Blattner & Frazier, 2002; Ruder & Martich, 2015), problem based learning (Boleng & Maasawet, 2019), and guided inquiry (Ardian, Hariyati, & Afifah, 2019).

CONCLUSION

According to the results of the study, it can be deduced that there are discrepancies in critical thinking skills between male and female students with a significance value of 0.044. The results of data analysis showed that the average score of critical thinking skills of male students was 2.60, and female students were 2.99, both of them have criteria not yet increased or underdeveloped. Disparities in critical thinking skills between male and female students are natural because men and women have different ways of thinking. Eventually, we suggest that to enhance the student's critical thinking skills, learning model variation should be implemented.

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