

## Critical Thinking Skill and Independence on Learning Natural Science Based on Gender During the Covid-19 Pandemic

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### ABSTRACT

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To improve students' critical thinking skills, this study used online PBL (Problem-Based Learning) on learning Natural Science in the field of Biology. This research was conducted in pre-experimental research design with the subjects of 4th semester students in study program of PGMI (Teacher Education of Madrasah Ibtidaiyah). The results of the analysis showed that the improvement of critical thinking skill of female students is better than male groups. Based on the results of the hypothesis testing obtained from the data showed that the  $N\_Gain$  critical thinking skill of male and female students were greater than  $\alpha$  (sig.  $0.051 > (\alpha) 0.05.$ ), therefore  $H_0$  was accepted and  $H_1$  was rejected. That is, there is no difference in the improvement of critical thinking skill between male and female students. When it came from the indicators of critical thinking, the  $N$ -Gain score for all indicators of the female group was better than that of the male one. Also, for students' independence, the average percentage of student responses in all aspects showed that they were in a Good category. The average percentage of student responses on the planning aspect was 73.65% in a Good category. The process aspect of student independent learning had the highest score among the three aspects, which was 75.73% or in the Good category, and the Learning Evaluation Aspect has the lowest score among the three aspects, which was 66.53% and was in a Good category.

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## 1. INTRODUCTION

In the process of critical thinking, an effort and an open-minded thought to new ideas are needed (Fisher, 2009). There are 5 activities used as benchmarks for critical thinking in solving problems, namely: (1) Looking for a brief statement of each question; (2) Looking for reasons; (3) Trying to know the information well; (4) Having an open-minded thought and attitude; and (5) Seeking as much explanation as possible (Yustyan et al., 2015). Critical thinking skill can be improved by applying

scientific approach-based learning (Yustyan et al., 2015), think-pair-share (Kurjum' et al., 2020), problem-based learning (Birgili, 2015).

Law number 20 of 2003 in article 3 states that the purpose of education is to develop the potentiality of the students to become human beings who believe and fear of God Almighty, have a noble character, are healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizens. Referring to the contents of the law, it is clearly stated that one of the goals of national education to be achieved is the formation of a character of independence in each student. The Indonesian government through the Ministry of Education and Culture formulates independent character as attitudes and behaviors that are not easily dependent on people others in completing their tasks (Kemendikbud, 2003).

Independence cannot be obtained by quick means instantly but develops through a long and repetitive process. The character of independence can be described into four stages as follows: (1) Looking for other people (parents, experts, teachers, and peers) to ask for help completing certain tasks; (2) Doing it yourself through directions and advice from others, (3) Doing the exercises yourself repeatedly through procedures and steps for completion; and (4) Developing and creating other ways to get things done well (Muhammad, 2014). According to Bonds et al., the responsibility of an educator is not only to transmit knowledge, although knowledge is important, educators also cannot continue to transmit knowledge throughout the life of students. Equipping students with metacognition strategies can be a solution in developing students' abilities to become independent lifelong learners (Bonds et al., 1992).

Regarding gender differences in learning, experts generally agree that learning outcomes caused by gender differences as the result of gender bias at home and school environment. Although many cultures apply and have specific rules, there is a tendency for the same behavior between men and women (Meece & Scantlebury, 2006). According to Macoby, at the previous study, there are gender differences in several areas: (1) Men are superior in spatial visual reasoning; (2) Men are superior in quantitative and problem-solving skills; (3) Women are superior in comprehensive verbal, fluency in words, and communication; (4) Women tend to avoid risks (especially extreme risks) in situations of uncertainty (gambling); (5) Women are more easily persuaded to change the decisions they make; and (6) women tend to be less sure about the decisions they make (Maccoby & Jacklin, 1974). Therefore, in this study, an attempt will be made to compare critical thinking skills and independence in natural science courses between male and female students.

Natural Sciences courses are compulsory subjects in Teacher Education of Madrasah Ibtidaiyah study program (PGMI) of State Islamic Institute of Kediri. The topics in Natural Science lectures are basic provisions for students to be able to teach Natural Science later on in Islamic Elementary School or Madrasah Ibtidaiyah. In Natural Science lectures, students learn about scientific knowledge in the fields of biology, chemistry, physics, and the integration between those. The ability to think critically is very important to be instilled in students, especially PGMI students as the candidates of teachers in Madrasah Ibtidaiyah or Islamic Elementary School. These need to be done thus the students can see, observe, and solve various problems that they will encounter in the school environment. Students are accustomed to learning only by listening to the information explained by the lecturer without knowing the actual conditions in the field. Even though they will later go into the field area during their field experience practice and the real work.

Problem Based Learning (PBL) learning model is a learning model in which students work on authentic problems to compile their knowledge, developing inquiry and higher-order thinking skills, developing independence and self-confidence (Arends, 2012). Critical thinking skills are influenced by intrinsic and extrinsic drives. A person's personality and cultural background can affect a person's efforts to be able to think critically about a problem in life (Hassoubah, 2007).

To improve students' critical thinking skill, this study used online PBL in learning in Natural Science course in the field of Biology. The foundation of PBL is a collaborative process. Learners will compile knowledge by building reasoning from all the knowledge they have and from all that is

obtained as a result of interacting with other individuals (Sudarman, 2007). In PBL, educators make a problem according to the desired results based on the curriculum, characteristics of learners, and real-world situations (Golightly & Raath, 2015). PBL is based on the design of methods to improve critical analysis skills, self-directed learning, and problem-solving (Choi et al., 2014; Kamin et al., 2001). In problem-based learning, the teacher acts as a facilitator and assists students in reminding the theoretical knowledge that is relevant to the problems encountered and leads students to identify their misunderstanding (Walker & Heather, 2009).

From a theoretical perspective, PBL model can help create learning conditions that originally are only the transfer of information from lecturers to students to a learning process that emphasizes constructing knowledge based on understanding and experience gained both individually and in groups. The problems raised in PBL are real problems in the field (Hmelo-Silver & Barrows, 2006). A unique feature of PBL, the problems that arise in PBL learning do not have a single answer, which means that students must engage in exploration with several pathways of solutions. In PBL, students are freed to obtain key issues from the problem. In addition, seeing the phases of PBL, allows this model to be applied by online. The results of this study can contribute to the development of research at other levels of education.

## 2. METHODS

This research was conducted using pre-experimental research design (Sugiyono, 2013), by applying online Problem Based Learning (PBL). The research conducted from March 2020 to September 2020 at Teacher Education Study Program of Madrasah Ibtidaiyah (PGMI), State Islamic Institute of Kediri, East Java.

The research subjects were 4th-semester students of the PGMI in academic year 2019/2020 who took the Natural Science SD / MI courses in the field of Biology. The number of the students were 37. Subjects were taken from one of three classes where male and female classes were not separated. The male and female classes were totally 28 and 9 students. This was conducted with Static Group Pretest-Posttest Design (Fraenkelet, J.R., Wallen, N.E., Hyun, 2011; Sukmadinata, 2010). Static Group in this study assumes all subjects have the same abilities and are taught by the same lecturer.

Treatment was carried out by providing problem-based learning or PBL. The application of PBL was conducted via online by using an integrated application consisting of Google Classroom as the main learning media, while Youtube and Whatsapp as supporting learning media (Wulandari, 2020). Google Classroom was used to link on Youtube and Whatsapp by providing lists of information, assignments, and instructions. Youtube was used to provide learning material in the form of video or audio-visual media, while Whatsapp was used as a medium for small group discussions.

The research procedures include planning stage, implementation stage, and final stage. Planning stage was making a research instrument consisting of (1) Semester Lesson Plan (RPS), contains learning steps with online PBL, in this case, the researcher acted as a teacher; (2) Learning media, using learning videos uploaded on Youtube; (3) Student response sheets to Online PBL learning, the sheet was in the form of a Google Form distributed through Google Classroom; and (4) HOTS (based multiple-choice test items on Higher Order Thinking Skill) in the field of Biology. Implementation stage was carried out by providing treatment Problem Based Learning (PBL) via online with the syntax as shown in Table 1. Final stage was carried out by conducting data analysis, discussion, and drawing research conclusions.

**Table 1.** Syntax Problem Based Learning (PBL) conducted via online

Syntax	Lecturer Activities	Students Activities
Phase 1 Students' orientation to problems	The lecturer raises problems related to the material or topics through Google Classroom Application The lecturer asks students to read and understand the problem by working individually based on the material provided If there are students who have problems, the lecturer will invite other students to give their responses. Then the lecturer provides classical assistance in the form of a link of Youtube video attached in the Google Classroom.	Students provide feedback briefly in the comment's column on Google Classroom. Students work individually to read and understand problems  Students provide feedback then listen to the learning videos, and record important information.
Phase 2 Organizing students to study	The lecturer divides students through WhatsApp attached in the Google Classroom to divide students into heterogeneous groups based on ability, gender, culture, and religion. The lecturer distributes Student Activity Sheets (LAM) contain of steps and problem solving	Students are divided into groups and the lecturer as a member of the group monitor students' discussions.
Phase 3 Guiding individual and group investigations	The lecturer asks students to collaborate to solve the problems and think carefully about solving strategies that are useful for problem solving. The lecturers pay close attention to students' work, observe and find various difficulties experienced by them, and provide opportunities to ask questions have not been understood yet. The lecturer provides assistance (scaffolding) related to the students' difficulties either from working individually or in groups, and encourage them to work together in groups	Students are engaged in discussions through WhatsApp group.  Students are engaged in discussions and ask questions when they have difficulties in understanding the problems.  Students are engaged in discussions and listen to feedback from the lecturer.
Phase 4 Developing and presenting the work.	The lecturer asks students to prepare reports on their results of group discussions in a good order, detailed, and in a systematic manner. The lecturer observes student's work to compile reports on their results of discussions in WhatsApp group, providing assistance when needed.	Students make reports on their results of group discussions in a good order, detailed, and in a systematic manner

	The lecturer asks students to determine (present) a report in front of the class.	Each group presents the results of the discussion in the comments column on Google Classroom.
Phase 5 Analyzing and evaluating the problem-solving process.	The lecturer provides evaluation questions about the material presented via google form.	

The data in this study are in the form of critical thinking test results and students' response data to the application of online PBL for male and female group students. The data collection instruments used were critical thinking test questions and attitude scale questionnaires to determine students' responses.

The improvement of students' critical thinking skill is known after the application of online PBL obtained by calculating the normalized average value of gain (N Gain). This is intended to avoid mistakes in interpreting the gain of each student (Gunawan & Liliasari, 2013). The formula (Hake, 1998) used is:

$$\langle g \rangle = \frac{\%(S_f) - \%(S_i)}{100 - \%(S_f)}$$

with  $\langle g \rangle$  is a normalized gain value,  $S_f$  is the average value of posttest, and  $S_i$  is the average value of pretest. According to Hake (1998, p. 66), the interpretation of the average gain value normalized ( $\langle g \rangle$ )  $< 0.3$  with the low category;  $0.3 \leq \langle g \rangle < 0.7$  middle category; and  $\langle g \rangle \geq 0.7$  with high category.

After the normalized average gain value for the two groups is obtained, it is then compared to see the difference in the improvement of students' critical thinking skill between the two groups. If the normalized average gain value of one class is higher than the normalized gain average of the other classes, then it is said that there is an effect of students' gender differences in the achievement of critical thinking skills.

The hypothesis testing used is a one-sided t-test for the upper side. This t-test uses SPSS 25 software with two independent samples t-test. The purpose of having two-variable t-test is to compare or differ whether the two variables are same or different. The point is to test the ability to generalize the significance of research results in the form of a comparison of two sample averages (Riduwan & Sunarto, 2013).

### 3. FINDINGS AND DISCUSSION

#### Validity and Reliability of Test Items

Students' critical thinking skills are based on 5 indicators, namely: 1) Looking for a brief statement of each question; (2) Looking for reasons; (3) Trying to know the information well; (4) Having an open-minded thought and attitude; and (5) Seeking as much explanation as possible (Yustyan et al., 2015). Those indicators are presented in blueprint described in Table 2.

**Table 2.** Blueprint of critical thinking items

Indicator	Description of the items	Question Number
Looking for a brief statement of each question	Making questions and statement from pictures	1, 5, 10, 11, 15, 20, 22
Looking for reasons	Looking for reasons about meaning or definition	9, 14, 16
Trying to know well information	Creating information in the environment.	2, 7, 8, 19, 21, 23, 24, 25, 26

Be open-minded	Be open minded to what is happening around you	3, 17, 18, 30
Seeking as much explanation as possible	Explaining the benefits, functions, and other descriptions of the image.	4, 6, 12, 13, 29

The items consist of 30 multiple-choice questions. In this matter, the validity and reliability tests were carried out. The validity test was carried out by an expert (expert judgment), the result found that there were two items were invalid, namely questions number 27 and 28. Then there were totally 28 items in multiple-choices were analyzed by using SPSS application to determine the reliability. The results of the analysis show that the reliability of the questions has a value of = 0.785. This value is greater than 0.6 thus the students' critical thinking skill instrument can be said reliable. The questionnaire is said reliable if the Cronbach Alphas value is more than 0.6 (Sujarweni, 2014).

### Improving Students' Critical Thinking Skill

The type of treatment given to students is PBL (Problem Based Learning) which is conducted via online. While the questions of critical thinking skills given are 28 items, thus, the highest score that can be achieved is 28. Questions of pretest were given before students receive learning treatment to determine students' initial skill. Furthermore, after being given learning treatment, students were given a critical thinking test again for the second time. The descriptive data is presented in Table 3.

**Table 3.** Descriptive statistics of critical thinking skill between male and female group student

Type of Test	N	Minimum	Maximum	Mean	Std. Deviation
Pretest_Male	9	10*	20*	16.22	3.383
Posttest_Male	9	14*	24*	19.78	2.991
Pretest_Female	28	6*	21*	14.32	3.888
Posttest Female	28	14*	27*	20.61	3.010

\*) Core of value is 28

Based on Table 3, there is a difference in the average score of students' critical thinking skill between male and female groups. The average pretest score of male groups was 16.22 from the ideal score of 28, while the average pretest score of female groups was 14.32. The mean of posttest score of female groups was slightly higher than the male group in which the score of each group is 19.78 and 20.61.

Students' critical thinking skill also shows different score between male and female group both before and after being given the learning treatments. The improvement on students' critical thinking skill is achieved from the normalized gain (N\_Gain). The differences in the achievement of critical thinking skills between male and female students are presented in Table 4.

**Table 1.** The differences in the achievement of critical thinking skills based on N\_Gain

Groups	Pretest	Posttest	N_Gain	N_Gain (%)	Categories
Male	16.22*	19.78*	0.27	26.81	Low
Female	14.32*	20.61*	0.47	47.06	Middle

\*) Core of value is 28.

Based on Table 4, there are differences in the achievement of students' critical thinking skills between male and the group. The highest achievement of the posttest and N\_Gain was achieved by female group, while the highest achievement of the pretest was achieved by the male group. The comparison of N-Gain between the male group was 26.81% (low category) and the female group was 47.06 (middle category). Thus, the improvement in critical thinking skill of female students is better than the males' ones. In this case, the application of Problem-Based Learning also has the same results in Mathematics, where the average problem-solving ability of female students is higher than male

students' (Davita & Pujiastuti, 2020). However, these differences must first be tested by the research hypothesis to determine the significance of the improvement. Whether or not the difference in the improvement that occurs in the two aspects of critical thinking are meaningful.

Research hypothesis testing is intended to determine the improvement in critical thinking skill after getting PBL (Problem Based Learning) via online by using the average difference test. N\_Gain is used to compare two independent samples. Based on the prerequisite test, the N\_Gain data for critical thinking is normally distributed with the recommendation of a parametric statistical test using the t-test. The results of the test for N\_Gain of critical thinking presented in Table 5. Meanwhile, the hypothesis testing for the improvement of students' critical thinking skill is formulated as follows.

H0: There is no difference in the improvement of critical thinking skill between male and female students.

H1: There is a difference in the improvement of critical thinking skill between male and female students.

In which H0 is rejected if  $(sig.) < \alpha = 0.05$  and H0 is accepted if  $(sig.) \geq \alpha = 0.05$ .

**Table 5.** T test N\_Gain students' critical thinking skill

		Independent Samples Test								
		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
N_Gain	Equal variances assumed	4.923	.033	-3.030	35	.005	-20.24192	6.68054	-33.80414	-6.67970
	Equal variances not assumed			-2.232	9.506	.051	-20.24192	9.07095	-40.59650	.11266

Based on the results of Independent Samples Test in Table 5 by using SPSS, it can be described that the sig. (2-tailed) obtained from N\_Gain data that the ability to think critically between male and female group students is greater than  $\alpha$  ( $sig. 0.051 > (\alpha) 0.05$ ), therefore H0 is accepted and H1 is rejected. That is, there is no difference in the improvement of critical thinking skill between male and female students. This result is supported by the statement that men and women appear to have similar cognitive abilities. On career aspirations, girls are more likely to choose careers that will not interfere with their future roles as spouses or parents. Meanwhile, boys have higher long-term expectations for themselves (Arends, 2012).

Overall, the results shown in this study indicate that there is an improvement in critical thinking skills. Where in other research, increasing critical thinking can be done through practicum activities (Yustyan et al., 2015), inquiry/discovery learning (Ahmatika, 2016; Haeruman et al., 2017), the use of interactive multimedia (Husein et al., 2015), metacognitive instruction approach (Noordiana, 2018), project-based learning (Insyasiska et al., 2015).

**Critical Thinking Skills Viewed from Each Indicator**

Critical thinking skill of each indicator are obtained through the average normalized value of the gain between the two groups. Furthermore, these values are compared to see the difference in the increase in student critical thinking. If the normalized average gain value of one group is higher than

the normalized gain average of the other groups, then it is said that there is an effect of gender differences in students' critical thinking achievement on each indicator. The description of the improvement by the mean N-Gain of each indicator between male and female groups are presented in Figure 1.

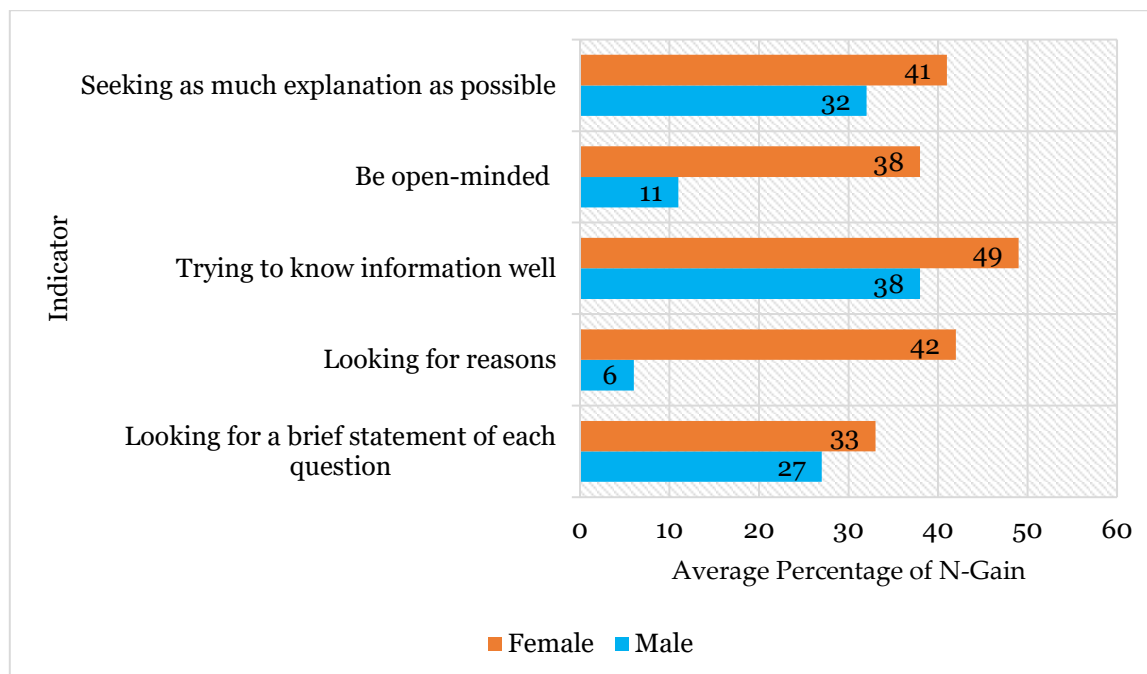


Fig. 1. Average percentage of N-Gain of each indicator

From Figure 1, it is said that N-Gain value for all indicators of the female group is better than the male group. This difference may be because women spend more time learning science which is fun learning science. Therefore, the achievements in scientific explanation or explaining scientific phenomena have a better value. As revealed in the survey, the General Certificate of Secondary Education (GCSE) shows that chemistry and biology are better for girls, and physics is the same for both, while boys are superior in mathematics (Evans, 2012). Those who have high scores on science test tend to have a more positive attitude towards science (Hariadi & Salim, 2010).

The first indicator is "seeking as much explanation as possible if needed", both male and female groups have an average N-Gain, 41% and 32% which are in the middle category. This is related to the phenomenon that students do not only learn based on what is obtained theoretically but are directly related to the realities that occur in the field (SD). The higher the relevance of the problem, the higher their willingness to work to solve the problem (Fakhriyah, 2014).

The second indicator is "having an open-minded thought and attitude," the male group has an average N-Gain of 11% which is included in the low category, while the female group gets 38% in the middle category. Having an open-minded thought attitude and thinking is a part of the attitude of science, therefore this condition is following the research of Afriana et al. (2016) which resulted that the improvement in science attitudes in the female class was better than those who were in the male class.

The third indicator is "trying to know information well" which has the highest achievement among the other four indicators. The average N-Gain obtained by the male and female groups was 38% and 49%, both of those were in the middle category.

In the fourth indicator "looking for reasons", the scores of the male and the female group have the farthest difference, in which the male group is 6% in the low category, while the female group is 42% in the middle category.

In the fifth indicator, “looking for a brief statement of each question”, male and female groups had an average N-Gain of 27% and 33%. Although the two differences are not that big, but they are in different categories, men are categorized as low, and women are categorized as in the middle. The results shown by the five indicators are supported by the reasons because women prefer to study biology or science related to future job choices (Hango, 2013).

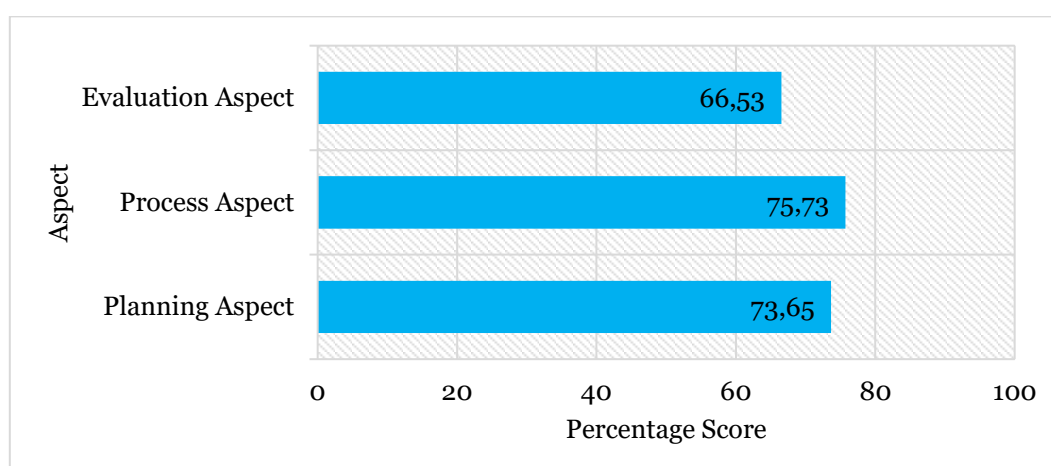
### Students' Independence Towards Online PBL (Problem-Based Learning)

The application of online PBL (Problem Based Learning) for students is inseparable from the students' efforts in learning independently. To determine the independence of students in the application of online PBL in the Natural Science subject in field of Biology, an attitude scale questionnaire was used. Student responses to learning are given after the online PBL stages are completely completed. The questionnaire statement on student responses to learning shows independence in participating of distance learning. 3 aspects are used to see the independence of student learning, namely: (1) Planning aspect; (2) Process aspects; and (3) Evaluation aspect. Determination of the level of student learning independence is categorized using TCR (Respondent Achievement Level) which is described in Table 6.

**Table 6.** Categorization of Respondents' Level of Achievement (Sugiyono, 2012)

Achievement Percentage (%)	Category
85 – 100	Excellent
66 – 84	Good
51 – 65	Average
36 – 50	Fair
0 – 35	Poor

Giving questionnaires about online independent learning aims to collect data on student responses towards student attitudes after online learning has been completed. The attitude scale used consists of 46 positive and negative statements. The questionnaire includes 8 statements for the planning aspect, 32 statements for the process aspect, and 6 statements for the evaluation aspect. Each statement has 4 scale options consisting of Always, Often, Sometimes, and Never. The results of student independent learning can be seen from 3 aspects shown in Figure 2.



**Fig. 2.** Students' independent learning on conducting online learning

The average percentage of students' responses in all aspects shows the results that are in the Good category. The average percentage of students' responses on the planning aspect is 73.65% in the Good

category. In this aspect, the highest value is obtained in terms of borrowing stationery, which is 87.50%. Most of the students gave their responses that they never borrowed stationery from their family members. This means that most students have their writing tools. Meanwhile, the lowest score in the Planning Aspect is in the statement "I determine the time outside of lectures for independent study", which is 60.83%. This shows that students' awareness of independent learning is still in the Enough category.

Process aspects of student independent learning have the highest score among the three aspects, which is equal to 75.73% or in the Good category. In this aspect, the highest score is in the statement "I access the material using ICT-based learning resources", which is 92.50%. This shows that students are accustomed and proficient in using technology to find the information needed in the Excellent category. While the lowest score is that students need the help of lecturers and friends in completing assignments. In independent learning, this does not indicate the independence of students in learning. In this statement, the value obtained is 52.50% or in the Average category.

The Learning Evaluation aspect has the lowest score among the three aspects, namely 66.53%, and is in a Good category. In this aspect, the highest score is in the statement "I know my weakness in learning", which is 80.83%. This shows that students are aware of their shortcomings in learning so that it can be an impetus for better independent learning. Meanwhile, the lowest score is in the statement "I feel that online learning is more comfortable than face-to-face", which is 45.83%. This shows that students do not like online learning, this shows that student responses to online learning are in the Poor category.

#### 4. CONCLUSION

This study applies online Problem Based Learning (PBL) into 2 groups, namely the male and female group. The conclusion of this study shows that N-Gain of the male group is 26.81% in the Low category, while the female group is 47.06% in the Middle category. Therefore, the improvement in critical thinking skills of female students is better than the male group. Then, based on the Independent Sample Test, it is stated that H0 is accepted and H1 is rejected, which means that there is no difference in the improvement of critical thinking between male and female students. When it is viewed from each indicator, it is known that the N-Gain value for 5 indicators of critical thinking in the women's group is better than the male group. This study also analyzes students' independent learning via online. From these activities, it was obtained that the average percentage of student responses in all aspects showed the results that were in the Good category. Where the planning aspect got a score of 73.65% (Good), the aspect of the process of student learning independence had the highest score among the three aspects, which was equal to 75.73% (Good), and the Learning Evaluation aspect had the lowest score among the three aspects, namely 66.53% (Good).

The weakness of this research is that this research is still specifically carried out at the university level. The results of this study can be used to develop further research at the elementary and high school levels. So that students' critical thinking skills and independence can be obtained completely at all levels of education

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