The impact of problem based learning model through e-learning on students’ critical thinking ability

I D Martyaningrum1*, D Juandi2 and A Jupri2

1Master program of Mathematics Education, Universitas Pendidikan Indonesia, Jl. Dr.Setiabudi No. 229, Bandung 40154, Indonesia
2Departement of Mathematics Education, Universitas Pendidikan Indonesia, Jl. Dr.Setiabudi No. 229, Bandung 40154, Indonesia
*ikadeavy@upi.edu

Abstract. This research is motivated by long distance learning and the importance of critical thinking ability. Several previous studies relating to critical thinking ability were about understanding students' critical thinking ability based on gender and students’ characteristics of lower and upper group critical thinking ability. However, almost no research could be found on students’ critical thinking ability who have learned with problem-based learning model through e-learning and students’ characteristics of middle critical thinking ability. Therefore, this study aims to identify students’ critical thinking ability who have learned with problem-based learning model through e-learning. The method in this study was qualitative with case-study approach. We gave a learning with problem based learning model through e-learning and a written test to 36 students on 8th grade students of one junior high school in Banyumas, Central Java. Then, we conducted interviews to 2 upper group students, 2 middle group students, and 2 lower group students. The results show that the students with upper, middle, and lower group critical thinking ability have different characteristics in each indicator of critical thinking ability. Meanwhile, the student who have learned with problem-based learning models through e-learning dominant in middle group critical thinking ability.

1. Introduction
The critical thinking ability is an important ability for students because influence on the success of learning, working, and living in the 21st century [1, 2, 3]. The critical thinking ability will supply someone to not easily act and trust information without observing, associating based on experience, and logical reasoning. A person with the critical thinking ability will evaluate, assess, and improve their thoughts continuously to finding and differentiating between right and wrong, logical and illogical, as well as relevant and irrelevant[4].The importance of critical thinking ability contradicted with facts that student's critical thinking ability in lower group[5, 6]. The students can't understand the interrelationship between concepts and connect the solution to the problem that solved[5]. Several previous studies relating to critical thinking abilities were about understanding students’ critical thinking abilities based on gender [7] and students’ characteristics of lower and upper group critical thinking abilities [8, 9, 10, 11].

Problem based learning is one of model with active learning and student-centered. Student-centered learning can improve students’ critical thinking to solved the problems[12]. Problem based learning is effective for students’ critical thinking ability [13, 14, 15]. The main of problem based learning is to
give authentic problems and meaningful learning to students and also facilitate students to investigate and reason. Problem based learning implementation encourages students to have critical thinking ability in various activities such as asking questions and discussing problems [16].

E-learning is the use of internet technology to distribute a series of solutions in improving knowledge or skills [17]. The benefits of using e-learning can be achieved anywhere and whenever with interactive, effective, easily accessible features, and training students more independently in acquiring knowledge. E-learning enables the students to express themselves using internet media, intranet, or other computer network media. It has a positive impact on motivation and student performance in elementary school[18]. E-learning used in this study is google classroom and WhatsApp application. The Google Classroom and WhatsApp applications were top-ranking media that students liked during the covid-19 pandemic [19].

Based on the above description, this research is aims to identify students' critical thinking ability who have learned with problem-based learning model through e-learning. In this way, we can get useful information about the characteristics of the students' critical thinking ability and the implementation of problem based learning through e-learning.

2. Methods
The method used in this research was qualitative with case-study approach. The study was implemented on 36 students of 8th grade Junior high School in Banyumas, Central Java. Data collection was conducted using observation, critical thinking ability written tests, and interview. First, we gave the learning with problem based learning model through e-learning. Observation aims to observe student activities and interactions that occur during the learning process. Then, we gave written test critical thinking ability. Written test instrument consist of six questions about surface area and volume of cube, cuboid, Prism, and Pyramid. It was constructed by indicators of critical thinking ability include checking the truth of an argument, making the conclusions, analyzing the proof and the algorithm, identifying the sufficiency of the data to choose the right strategy. The students' answers used to determine the category of critical thinking ability and then selected 2 students from upper group, 2 students from middle group, and 2 students from lower group. Six selected students got interviews by researcher.

3. Result and Discussion
The result of this study are presented in Figure 1 which describe the group distribution of students' critical thinking ability based on the result of written test.

![Figure 1. Group Distribution of Students' Critical Thinking Ability](image)

Figure 1 shows that the student's critical thinking ability who have learned with the problem-based learning model through e-learning is dominant in the middle group. Students in upper critical thinking ability group only 11%. Next, we describe the students' critical thinking ability of students who have
learned with the problem based learning model through e-learning based on the group of students' critical thinking ability.

In the first indicator namely checking the truth of an argument, students in upper group can give more detailed reason and comprehensive explanations using their own language compared to students in middle group. They can solve problems with a clear and broad perspective. They can present data clearly, thoroughly, and precisely. The explain concepts ability with students' own words is proof that students have the critical thinking ability in upper group [20].

In the second indicator, students must be able to identify the relation between the concepts involved in the problem for making the conclusions exactly. It can be implemented by students in upper group. Another case in middle group, they can’t identify relation between the concepts so that nothing the conclusions was given. Students in upper group can build rational and logical thinking and also have a broad perspective. Students in lower group can’t find this indicator. They don't have the ability to make the conclusions. This was also according to previous researches [7, 9].

The third indicator is the proof and algorithm analyzing. Students in upper group have difficulty in proof analyzing that include the mathematical symbols. Students have obstacles in starting mathematical proof. This was also according to previous researches [19]. The ability to visualization in writing geometry proof is not enough for the success of proving [21]. The upper students substituted an specific number to the formula. It was to increase their confidence about their answer. They are superior in analyzing mathematical proofs than algorithms. Lower student can’t analyze the proof and algorithm. This is because they difficulties in understanding of concepts [16] and made mistakes in choose or applying the strategies. It was also according to previous research [22], namely half of the students used informal rather than formal algebraic strategies in solving geometry problems and they made mistakes in applying algebraic strategies.

All of group critical thinking ability can achieve the fourth indicator, namely identifying the sufficiency of the data to choose the right strategy. They can identify the data that is known, asked, and found sufficiency the data and completed the required data exactly. However, upper group students wrote the more detailed and clearly answers.

Students have different ways to solve the problems and different opinions to describe the reason. Figure 2 and 3 show students' written work on the fourth sections problem. Figures 2 and 3 show that students solve problems using formal and informal proof and they can make a conclusion with a different reason. We know that making a conclusions and analyzing the proof and algorithms are indicators of critical thinking ability. Problem Based Learning encourages students to have a positive attitude towards learning [23] and encourages students to have critical thinking in various activities that involve the problems.

Problem Based Learning through by e-learning in the first meet had not been coloured by the students' active participation. Using a problem and their critical thinking ability to solve a problem in learning was unusual for the most of students. Based on interviews with the students, they had never followed the learning that begins with a problem and use e-learning. They felt helped by this learning activities during the learning from home, although they can’t get a lot of knowledge same as in face-to-face learning. Some of students send late assignments and sometimes the collected assignments not answer the problems. In implementing Problem Based Learning model through e-learning, teachers must monitor and remind students to understand, learn, and complete the assignments frequently.
The question: Mother bought one box of fruit salads.
Size of the box are 30 cm × 30 cm × 30 cm.
Mother will give the salad for six fruit containers. It is a Pyramid shape with base 30 cm × 30 cm and height 15 cm. Can the six containers be fully charged with salads? is there any salad residu? Why?

Translated version of the answer:

\[
\text{Volume of cube } = S \times S \times S = 30 \text{ cm } \times 30 \text{ cm } \times 30 \text{ cm} = 27000 \text{ cm}^3 = 27 \text{ dm}^3
\]

\[
\text{Volume of pyramid } = \frac{1}{3} \times \text{area } \times \text{high } = \frac{1}{3} \times (30 \times 30) \times 15 \text{ cm} = 300 \times 15 = 4500 \text{ cm}^3 = 4.5 \text{ dm}^3
\]

\[
\frac{V_{\text{cube}}}{V_{\text{pyramid}}} = \frac{27}{4.5} = \text{six pyramids}
\]

So, all of the pyramids will be fully charged with salads because the volume of the pyramid is equal to 1/6 of the volume of the cube.

Figure 2. Example 1 of Students’ Written Work on the Fourth Sections Problem

Translated version of the answer:

Six pyramids will be fully of fruit salads because a cube consists of six pyramids that have the same large. So, a pyramid will be full of fruit salads from the mother.
The volume of salad cube equals much fruit salads \(=S^3 = 30^3 = 27000 \text{ cm}^3\). So, much of fruit salads in a pyramid \(= \frac{27000}{6} = 4500 \text{ cm}^3\)

Because of the pyramid box have the same length, then the salads in the cube box can be divided evenly into 6 pyramid box.

Figure 3. Example 2 of Students' Written Work on the Fourth Sections Problem
4. Conclusion
Upper group students can check the truth of an argument exactly, give a detail explanation and correctly, identify the processes or concepts involved in the problem, identify the relationships between the concepts involved so that they can make conclusions exactly, analyze the algorithm or procedure. However they have difficulty on proof analyzing that include the mathematical symbols. They have more detailed and clearly answer. Middle group students can check the truth of an argument, give a brief explanation, identify some of the concepts involved, dominant on analysis of mathematical proof rather than the algorithm, but they can’t identify the relationships between the concepts involved so that nothing conclusions was given. Lower group can’t identify the problems and data needed to solve problems so they are unable to check the truth of an argument and make a conclusions based on the processes/mathematical concepts involved, and cant analysis of the algorithm and proof correctly. It takes a time to learn and introduce problem based learning and e-learning technology for students to create challenges and create more effective learning so that can have more influence on students' critical thinking ability. Based on these results, the researchers suggest to: 1) use a different learning material scope with longer time implementation to obtain a more complete picture about the students' critical thinking ability who have learned with problem based learning model, and 2) enhancement the students' critical thinking ability.

5. References
[1] Bermingham M, 2015 Clearing up “Critical Thinking”: Its Four Formidable Features Creat. Educ. **06**, 04 p. 421–427.
[2] Kivunja C, 2015 Using De Bono’s Six Thinking Hats Model to Teach Critical Thinking and Problem Solving Skills Essential for Success in the 21st Century Economy Creat. Educ. **06**, 03 p. 380–391.
[3] Zare P and Othman M, 2015 Students’ perceptions toward using classroom debate to develop critical thinking and oral communication ability Asian Soc. Sci. **11**, 9 p. 158–170.
[4] Paul R W Elder L and Bartell T, 1997 California Teacher Preparation for Instruction in Critical Thinking: Research Findings and Policy Recommendations p. 194.
[5] Arini W and Juliadi F, 2018 Analisis Kemampuan Berfikir Kritis Pada Mata Pelajaran Fisika Untuk Pokok Bahasan Vektor Siswa Kelas X SMA NEGERI 4 J. Ilmiah Fisika, Pemb. dan Aplikasinya **10**, 1 p. 1–11.
[6] Nuryanti L Zubaidah S and Diantoro M, 2018 Analisis Kemampuan Berpikir Kritis Siswa SMP J. Pendidik. Teor. Penelitian, dan Pengemb. **3**, 2 p. 155–158.
[7] Zetriuslita Ariawan R and Nufus H, 2016 Students’ critical thinking ability: Description based on academic level and gender J. Educ. Pract. **7**, 12 p. 154–164.
[8] Rudd R Baker M and Hoover T, 2000 Undergraduate Agriculture Student Learning Styles and Critical J. Agric. Educ. **41**, 3 p. 2–12.
[9] Brabeck M M, 1983 Critical thinking skills and reflective judgment development: Redefining the aims of higher education J. Appl. Dev. Psychol. **4**, 1 p. 23–34.
[10] Usher E L, 2009 Sources of middle school students? self-efficacy in mathematics: A qualitative investigation Am. Educ. Res. J. **46**, 1 p. 275–314.
[11] Gao J, 2020 Sources of Mathematics Self-Efficacy in Chinese Students: a Mixed-Method Study with Q-Sorting Procedure Int. J. Sci. Math. Educ. **18**, 4 p. 713–732.
[12] Ulfiana E Mardiyana and Triyanto, 2019 Determining ways to improve critical thinking skills in the math mathematics in student style J. Phys. Conf. Ser. **1321**, 2.
[13] Iwaoka W T Li Y and Rhee W Y, 2010 Measuring gains in critical thinking in food science and human nutrition courses: The cornell critical thinking test, problem-based learning activities, and student journal entries J. Food Sci. Educ. **9**, 3 p. 68–75.
[14] Alwis W A M and O’Grady G, 2002 One day, one problem: PBL at the Republic Polytechnic Citeseer December p. 1–8.
[15] Aini N R Syafiril S Netriwati N Pahrudin A Rahayu T and Puspasari V, 2019 Problem-Based
Learning for Critical Thinking Skills in Mathematics *J. Phys. Conf. Ser.* **1155**, 1.

[16] Asysyifa D S, J Wilujeng I and Kuswanto H, 2019 Analysis of Students Critical Thinking Skills Using Partial Credit Models (PCM) in Physics Learning *Int. J. Educ. Res. Rev.* p. 245–253.

[17] Sanderson P E, 2002 How to assess memory loss in the elderly *Patient Care* **33**, 5 p. 197–211.

[18] Ibrahim D S and Suardiman S P, 2014 Pengaruh Penggunaan E-Learning Terhadap Motivasi Dan Prestasi Belajar Matematika Siswa Sd Negeri Tahunan Yogyakarta *J. Prima Edukasia* **2**, 1 p. 66.

[19] Mustakim, 2020 Efektivitas Pembelajaran Daring Menggunakan Media Online Selama Pandemi Covid-19 Pada Mata Pelajaran Matematika the Effectiveness of E-Learning Using Online Media During the Covid-19 Pandemic in Mathematics *Al asma: Journal of Islamic Education* **2**, 1 p. 1–12.

[20] Choy S C and Cheah P K, 2009 Teacher Perceptions of Critical Thinking Among Students and its Influence on Higher Education *Int. J. Teach. Learn. High. Educ.* **20**, 2 p. 198–206.

[21] Jupri A, 2016 Seeing the unseen in words and symbols: The role of visualization in writing geometry proofs *Proc. Int. Conf. Educ. Psychol.* p. 163–169.

[22] Jupri A and Syaodih E, 2017 Between Formal and Informal Thinking: the Use of Algebra for Solving Geometry Problems From the Perspective of Van Hiele Theory *J. Pengajaran MIPA* **21**, 2 p. 108–113.

[23] Juandi D, 2006 Meningkatkan daya matematik mahasiswa calon guru matematika melalui pembelajaran berbasis masalah *Disertasi pada SPS UPI*. 