The effectiveness of blended learning on students’ critical thinking skills in mathematics education: a literature review

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Abstract. Critical thinking skills (CTS) is one of the required competencies in the 21st century. Using technology in this era is a common thing including in education. One of the learning methods assisted by technology is blended learning. In this study, the effectiveness of blended learning on students’ CTS will be analyzed. The method used in this study was a literature review. There were view steps to investigate the effectiveness of blended learning on students’ CTS namely providing the definition of blended learning, finding information about essential elements in blended learning, then synthesizing some previous studies on the implementation of the method to improve students' CTS and connecting the studies with blended learning. Based on the literature review result, the implementation of blended learning in Mathematics had the potential to improve students' CTS. This study could provide an overview of the problems and opportunities to implement blended learning in schools.

1. Introduction

Merdeka Belajar or the freedom to learn is a new policy in Indonesian education. The freedom to learn is interpreted as an effort to create a learning environment that gives students and teachers the freedom to express ideas and make the teacher focus on giving the best learning activities to achieve national education goals [1]. The reason behind the establishment of Merdeka Belajar was the excessive number of parents’ complaints to criticize the current national education system, where students only learn to meet specific standard values [2]. The purpose of education is not only to reach a specific standard value but also to develop students' thinking skills [3], which can be implemented by students in real life. Thinking skills are one of several competencies that students must have in the 21st century. There are four competencies essential for students in the 21st century: critical thinking and problem solving, creativity, communication skills, and ability to work collaboratively [4]. Critical thinking is also one of the educational goals that is teaching and developing students' critical thinking skills [5].

Critical thinking is an ability that tends to consider problems based on students' experience or knowledge and the skills in using rational thinking for the process of making decisions, behavior, and belief of a person [6], [7]. The ability to think critically is essential because critical thinking skills are needed to make decision-making [5], [8]. Moreover, in the era of the industrial revolution 4.0, critical thinking skills are needed in all aspects of life. Considering the importance of critical thinking skills, many researchers have conducted research related to students' critical thinking skills, including in Indonesia. Unfortunately, the research results related to Indonesian students' critical thinking skills
indicated that Indonesian students had low thinking abilities [9]–[12]. The students' low ability to think critically was caused by their tendency to focus on memorizing learning materials [13]. Therefore, a solution is needed to make students focus not only on memorizing learning materials but also on developing thinking skills, especially critical thinking skills, by implementing educational technology to improve learning activities [13]. It is common in most educational institutions to use technology during the learning [14], such as the use of technology in blended learning.

Blended learning is a combination of face-to-face learning with online learning, which maximizes the benefits of both learning methods [15]. Several previous studies indicated that students' critical thinking skills could be fostered by online learning [3], discussion [16], [17], and students' activities in class, which demand students to think critically accompanied by exercises and assignments [18], [19]. Thus, this study aimed to review students' critical thinking skills using blended learning or the combination of online learning and face-to-face learning methods. The purpose of discussing blended learning to improve students' critical thinking skills through literature review was to investigate the effectiveness of blended learning on students' critical thinking skills. This study was expected to provide an overview of the problems and opportunities in implementing blended learning in schools, which could help teachers improve students' critical thinking skills.

2. Methods
This study was a literature review of previous studies that aimed to investigate the effectiveness of blended learning implementation on students' critical thinking skills. This literature review included previous studies related to blended learning and critical thinking in Mathematics Education. There were eighteen articles about blended learning and critical thinking that had been selected from Google Scholar.

The steps to conducting the literature review about the effectiveness of blended learning on students' critical thinking skills were (1) identifying Mathematics education articles related to blended learning and critical thinking skills, (2) analyzing the definition of blended learning, (3) investigating information about the essential thing in blended learning, (4) synthesizing some information about the works done to improve critical thinking skills in the previous study, (5) analyzing the reason why blended learning is effective to improve students' critical thinking skills, and (6) making a conclusion.

3. Result and Discussion

3.1. What is blended learning?
Blended learning is the combination of face-to-face learning and online learning methods that maximize the benefits of both learning methods [15], and it became a common practice in all education levels [20]. The attribute of blended learning is that there is online learning with the use of educational technology. Educational technology employed in blended learning can be in the form of learning management systems (LMS), such as Edmodo, Moodle, Schoology, and others. LMS is an online learning platform that uses internet access. LMS has been widely used to facilitate online learning activities in blended learning for all subjects, including Mathematics. Denoting to the studies conducted previously, blended learning was a good way for students to learn Mathematics [21] since students were interested in learning mathematics by using blended learning [22], and teachers had more time to delve more to the materials [23].

Blended learning is an appropriate learning method to overcome face-to-face learning problems limited by the time [14], [24]. It assists teachers in extending and supplying classroom learning with online exploration [22] and helps students to learn anytime and anywhere without neglecting face-to-face interaction between students and teachers in the class [25]. Those implied that teachers did not have to worry about reaching the learning objectives due to the limited time. Besides being able to extend face-to-face classrooms, blended learning allowed students to have discussions about their learning problems with other students or teachers [22]. The discussion activities could be conducted using LMS because the LMS features allowed students to communicate with other students and teachers [14]. That signified that students had an opportunity to ask their teacher at any time without worrying about being
humiliated by others. In face-to-face learning, students were reluctant to ask or answer questions from the teacher since they felt embarrassed if they made mistakes in front of their peers [26], and they avoided their peers’ judgment over their “silly” questions for the teacher [27].

Furthermore, blended learning allowed students to learn and practice at their own pace [27], [28]. It had been noted that the teachers’ pace was considered too fast for the average students [28]. That demonstrated that using blended learning can assist students to learn and practice at their own pace. Therefore, it could maximize the development of students’ thinking skills.

Based on the previous studies, it can be concluded that the definition of blended learning is a modern learning method that integrates face-to-face learning with online learning methods, which includes media-rich technology used as a complement to face-to-face learning so that it can maximize students' thinking skills development.

3.2. Blended learning on critical thinking skills
Blended learning is the integration of face-to-face learning and online learning methods that have some features. The features extracted from several previous studies are presented in Table 1.

| Author(s) | Self-Paced Learning | Support Collaborative Learning | Support Discussion | Practice and Performance Support | Feedback Support | Support Knowledge Construct |
|-----------|---------------------|-------------------------------|--------------------|----------------------------------|-----------------|----------------------------|
| [29]      | ✓                   | ✓                             | ✓                  | ✓                                | ✓               | ✓                         |
| [27]      | ✓                   | ✓                             | ✓                  | ✓                                | ✓               | ✓                         |
| [22]      | ✓                   | ✓                             | ✓                  | ✓                                | ✓               | ✓                         |
| [28]      | ✓                   | ✓                             | ✓                  | ✓                                | ✓               | ✓                         |
| [21]      | ✓                   | ✓                             | ✓                  | ✓                                | ✓               | ✓                         |

Blended learning allowed students to study with various resources at their own pace [27], [28]. In the blended learning environment, students could access learning materials, learning videos, and other learning resources every time and everywhere [22], [29]. They could also learn the materials at their own pace, without being forced to follow other students’ pace. Thus, when students did not understand the learning material they learn in face-to-face classrooms, they could access the materials through online classrooms and review it at their own pace. It also gave students opportunities to encounter, explore, and reflect on ideas before engaging with them in the face-to-face classroom [22]. In other words, learning with blended learning was more flexible [21].

Furthermore, studies on blended learning showed that this learning method supported collaborative learning. Students could collaborate with their peers [21], [22], [28] outside the face-to-face classroom, and it enabled them to solve queries easily [28]. Besides, students could also have access to their teachers’ chat [29] to ask questions related to learning problems without worrying about classmates’ judgment [27]. Therefore, using blended learning could help students be more collaborative with other students and be brave enough to ask the teacher about topics they did not comprehend.

Accordingly, blended learning supported discussion [21], [22], [29] and ideas sharing with other students [28]. Blended learning provided opportunities for all students to participate in discussions [28] and make them more comfortable for asking questions [21] and doing discussion. Moreover, teachers could ensure the students’ active involvement during the discussion [30] to know the progress and development of their students. Consequently, when teachers did not know the development of their students because they were passive in class, online discussion on blended learning could provide the teachers with the students’ development.

The less distracting environment of blended learning could facilitate students to focus on their learning [27] and practice [22], [29]. Students who studied with blended learning had more time to practice [27]. Practicing in a digital environment inspired students and could be a fun way of learning [28]. Furthermore, online assessment on this blended learning was intended not only to offer
opportunities for students to practice but also to check students' understanding [28]. Blended learning created an atmosphere of learning that forced students to practice solving problems [21] and enjoy the situation. Students learning with blended learning were like really taking knowledge away from the course [21]. Besides being able to learn and practice, blended learning allowed students to obtain feedback from the teacher [22], [29] on their academic performance [28]. Finally, blended learning allowed students to master some concepts [21], [22], [27]–[29]. These features of blended learning were proven to support students to think critically.

3.3. Why is blended learning effective in critical thinking skills?

Critical thinking skills is an ability which tends to carefully consider problems based on the students' experience or knowledge and skills in using their rational thinking for making decision, behavior, and beliefs [6], [7]. This ability is regarded as an important skill since critical thinking skills are needed as the basis for making decisions [5], [8].

![Figure 1. The relationship between blended learning and critical thinking skills](image)

Figure 1 showed the learning activities to improve students' critical thinking skills [17]. The learning environment in blended learning facilitated students to think critically, discuss, and also practice without being limited by time and space.

There were some reasons why blended learning was effective in improving students' critical thinking skills. First, the learning environment could support students to think critically not only in the classroom but also outside the classroom through online learning. Previous studies indicated that critical thinking did not automatically emerge as a by-product of any Mathematics curriculum [31], but students' critical thinking could be formed in a learning environment that puts students in the situation to think critically [17]. The online meeting in blended learning allowed teachers to create a learning environment to think critically at any time so that students were accustomed to that situation. Second, blended learning could support students for discussion without being limited by time. This method provided an opportunity for all students to participate in discussion actively [19], do self-reflection and collaboration with other students to broaden their understanding on the learning material, evaluate a topic with other students, and construct their understanding on the learning materials by exploring questions and explaining ideas [32]. These activities could make students accustomed to thinking critically [33].

Finally, blended learning could create an atmosphere for students to practice without time limitation. Critical thinking could be successfully developed only if the teacher provided exercises which solution required critical thinking skills [17]. Blended learning facilitated teachers to provide exercises to students and feedback on their learning outcomes. All features in blended learning were proven to support students to be accustomed to critical thinking and had the potential to improve students' critical thinking skills.

4. Conclusion
Based on the result of the literature review, it can be concluded that blended learning was perceived as useful, enjoyable, and flexible learning for students. The learning environment in blended learning allowed students to master some concepts. Furthermore, students’ critical thinking skills could be improved if fostered every day by providing an environment that demanded students think critically. This learning environment should be supported by some exercises and discussions about which solution involving critical thinking skills. The most important thing to consider to improve students’ critical thinking skills was how they assess their answers, and the methods used to acquire the answers. Moreover, blended learning-enabled teachers provide students a learning environment that can support students to think critically every day both inside and outside the face-to-face classroom. Blended learning helped teachers provide exercises and enable them to communicate directly to students to delve their reason and further explanation related to students’ exercise and give feedback on student learning outcomes. Besides, this method accommodated opportunities for all students to engage in discussion. Therefore, blended learning could support all the activities needed to improve students’ critical thinking skills. In conclusion, based on the literature review results, the implementation of blended learning in Mathematics learning had the potential to improve students’ critical thinking skills. Further researchers are suggested to investigate blended learning applications to improve students’ critical thinking.

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