Problem-based Learning (PBL) Conducted Online: It's Potential in Developing Student Self-efficacy in Mathematics Learning

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**Abstract**. This literature study aims to examine the potential of Problem-based learning (PBL) in online mathematics learning in developing student self-efficacy. The steps that teachers take in PBL in general are; (1) identifying problems with students; (2) organizing students to learn; (3) helping students carry out investigations to solve problems, either individually or in groups; (4) helping students to present their work; and (5) analyzing the process and student learning outcomes. These steps can still be implemented online. Theoretically, these steps have the potential to develop student self-efficacy. Online PBL, if done correctly, will be able to develop students 'optimistic attitude, students' self-confidence in their abilities, persistence, and a positive attitude in dealing with changing situations. These are some of the indicators of self-efficacy.

1. **Introduction**

The world is experiencing problems with the Corona Virus Disease 2019 (COVID-19) pandemic. COVID-19 is not only spreading rapidly but has become a global pandemic affecting many things, especially in developing countries that have limited resources [1]. The existence of social distancing and physical distancing policies to reduce the number of COVID-19 transmissions has forced the government to change several systems. One thing that must change is the learning system. Learning must be done online to reduce the risk of teachers and students transmitting COVID-19 to each other.

In Indonesia, online learning is regulated through the Ministry of Education and Culture Circular Letter No. 4 of 2020 concerning the Implementation of Education Policies in an Emergency for the Spread of COVID-19 [2]. In implementing online learning, it has caused many problems. Among them, there are complaints from teachers, parents, and students as learning subjects with increasing workloads. Technically, online learning in Indonesia is still primarily concerned with assigning assignments and/or questions that students must then work on. The only difference lies in the medium of delivery. If all this time, the assignment and work of quizzes on practice questions were carried out in one classroom, then during this pandemic, the task in online learning was given and delivered via internet media, such as via web e-learning, WhatsApp between teacher-students, and other learning media.

For mathematics learning, in general, many teachers have implemented student-centered learning. One of the student-centered learning models is Problem-based Learning (PBL). Problem-based Learning (PBL) is a learning model characterized by real problems as a context for students to learn to think critically and to learn problem-solving skills, as well as to acquire knowledge [3]. By applying this PBL learning model, the teacher trains students to compile their own knowledge and develop their skills/abilities in solving the problems at hand. In principle, PBL is learning that makes problems as a basis or basis for students to learn [4].

Many studies conclude that PBL has a positive effect on student learning outcomes in mathematics [5, 6]. However, despite its many advantages, implementing PBL online is not an easy task for most mathematics teachers. Learning mathematics online is still a new thing. This raises several questions among math teachers. These questions include: (1) how to implement PBL online; and (2) whether online PBL can develop student self-efficacy?

Self-efficacy is the teacher's concern because it relates to problem-solving activities in PBL. Self-efficacy is a belief that someone is able to carry out an action and achieve certain goals [7]. Student self-efficacy has an influence on student attitudes in choosing assignments, persistence in doing assignments, and in responding to failure [8]. The existence of good self-efficacy is able to encourage someone to always try to learn and do tasks so that the task is successfully carried out. Self-efficacy is also considered important because mathematics is still considered a difficult subject by most students. Low self-efficacy can have an impact on students' low confidence to solve math problems.

Noting the advantages of PBL and the importance of self-efficacy for students in solving problems, the researchers consider it necessary to study the potential of PBL, which is implemented online in developing student self-efficacy. There are five sub-topics that will be discussed, namely (1) the Problem-based Learning (PBL) model, (2) online learning, (3) the online PBL model, (4) student self-efficacy, and (5) linkages. PBL models are implemented online with the development of student self-efficacy.

1. **Method**

This article is a literature review on knowledge, ideas, or findings related to PBL, online learning, and student self-efficacy. Data were obtained from scientific journals and relevant research results to obtain a review of how the potential of the Problem-based Learning (PBL) model was implemented online in developing student self-efficacy, especially in mathematics learning. Then the data were analyzed, and finally, the conclusion was drawn according to the research objectives, namely to suggest the potential of the Problem-based Learning (PBL) model, which was carried out online in developing student self-efficacy in mathematics learning.

1. **Result and Discussion**
	1. *Problem-based Learning Model*

According to Karatas [9], problem-based learning is a very important learning model in learning mathematics. PBL includes the process of analyzing, interpreting, reasoning, predicting, evaluating, and reflecting. The PBL model emphasizes authentic problems as they occur in everyday life [10]. According to Ardeniyansah [11], PBL as a learning model that can assist students in finding new ideas that affect creativity in learning. Problem-based Learning (PBL) is an invention-based learning model that can be used in mathematics learning and significantly assists students in achieving learning goals [12].

PBL provides benefits to students. According to Crowley [13], the benefits of PBL for students are mainly to help students develop problem-solving skills. The steps that teachers take in PBL in general are: (1) identifying problems with students; (2) organizing students to learn; (3) helping students carry out investigations to solve problems, either individually or in groups; (4) helping students to present their work; and (5) analyzing the process and student learning outcomes [11].

The following are some of the research results that support the advantages of PBL. Rahmantiwi et al. [10], in their research, showed that the application of the Problem-based Learning (PBL) model can affect the mathematics communication skills and curiosity of class X students. Then, Hidayati et al. [14], in their research, showed that PBL can improve students' mathematical communication skills, and student interest in learning. Ulger [15] in his research showed that PBL has a significant influence on creative thinking, but less influence on critical thinking disposition in fine arts education. Furthermore, Nurtanto et al. [16], in their research, showed that PBL was able to improve the quality of learning through character-based learning literacy and life career skills (LL-LCS). Padmavathy [17], in his research, showed that problem-based learning influences mathematics learning in increasing students' understanding and ability to use concepts in real life. From the description above, it can be seen that the problem-based learning (PBL) model has a positive impact on learning activities, mathematics communication skills, students' mathematical communication skills, learning interest, curiosity, creativity, critical thinking, mathematical problem solving, mathematical literacy skills, and so forth.

* 1. *Online Learning*

Online learning is an open and distributed learning system using pedagogical tools (educational aids), made possible through the internet and network-based technology to facilitate the formation of learning and knowledge processes through meaningful action and interaction [18]. In simple terms, Brown [19] states that online learning is a learning activity that utilizes networks (internet, LAN, WAN) as a method of delivery, interaction, and facilitation and is supported by various other forms of learning services. Learning online or online (in a network) is carried out through various applications that can support the learning process starting from face-to-face applications such as zoom, google meet, and other online media platforms such as google classroom, WhatsApp, and so on.

Along with the times, a person can get information easily through new technologies that are constantly evolving. This technological development can be beneficial in the field of education for both teachers and students. Online learning provides benefits to teachers and students, especially during a pandemic like now, which does not allow learning to be carried out offline. Another benefit of online learning, among others, is that it allows students to re-learn what the teacher has said, it is not limited to space and time. According to Siahaan [20], there are three functions of online learning for learning activities, namely: (1) as a supplement, (2) as a compliment, and (3) as a substitution. However, in order to provide optimal benefits, online learning still has to pay attention to the following principles, namely (1) having clear objectives, (2) relevant to needs, (3) quality of education, (4) program efficiency and effectiveness (5) independence (6) integrity and (7) sustainability.

Several research results conclude that online learning has advantages. Research conducted by Mustapha [21] concluded that online learning could increase HOTS in mathematics by using Polya's problem-solving model. Wang [22], in his research, showed that students felt learning satisfaction in the online learning process. Furthermore, Utami's research [23] shows that online learning has a positive effect on mathematics lessons. Muali [24], in his research, also showed that the learning outcomes of students who have visual, auditory, and kinesthetic learning styles have better critical thinking skills if given online self-learning based on Rich Internet Applications (RIA) than students who learn using conventional learning methods. From the description above, it can be seen that online learning shows a positive impact on learning, especially in learning mathematics.

* 1. *Problem-based Learning Conducted Online*

Based on the steps of problem-based learning and the principles of online learning, steps of problem-based learning can be arranged online. However, before learning takes place, the teacher must first ensure that students are ready with the tools/facilities needed to take part in learning, such as cellphones or laptops, and can use them properly. Teachers also have to consider the need for pulses for students. Therefore, teachers must be able to choose an online learning model that is affordable and can be followed by students. Then, the teacher can carry out learning with the following steps.

In the introductory stage, the teacher must explain the learning objectives and motivate students to engage in problem-solving activities. At the core stage, first, the teacher displays various problems in everyday life online according to the learning objectives. In this step, the teacher must provide instructions and opportunities for students to analyze the various problems that are displayed. Second, the teacher organizes the students to learn. Because learning online, the teacher must prepare problems that students must solve systematically. Third, the teacher encourages students to get the right information, perhaps through experiments, to get explanations and solutions to problems, both individually and in groups. To assign students to discuss in groups, the teacher must explain how to discuss online. The teacher has to make sure that the students actually discuss it in groups. Fourth, the teacher helps students to present the solutions to the problems they get. Fifth, teachers and students together look at the results of problem-solving obtained by students. In the closing section, the teacher evaluates the results of problem-solving that students are working on, provides reinforcement, provides additional explanations if needed, and draws conclusions.

Thus, in principle, PBL steps that are carried out online are the same as PBL, which is carried out offline. However, so that students understand what the teacher says online, the teacher must prepare to be able to answer student questions online as soon as possible. In general, students are more willing to ask their teachers indirectly. Teachers must also practice effective online interaction or communication with students or groups of students. Teachers also have to practice using various online media so that learning is not monotonous/boring to students.

* 1. *Self-efficacy*

Everyone needs the ability to judge himself. This ability is called self-efficacy. According to Perez [25], in an academic context, self-efficacy reflects how students are confident in performing certain tasks. Self-efficacy can also be interpreted as a person's assessment of his own ability to plan and implement actions to achieve certain goals [26].

Self-efficacy in learning mathematics is an aspect of the belief that a student has in solving math problems or assignments given by the teacher. Ertekin [27] stated that self-efficacy is a person's confidence in his ability to successfully conquer mathematical processes. Zimmermann et al. [28] also stated that the high self-efficacy of students in mathematics would encourage the achievement of good learning outcomes. Those who have high self-efficacy will be more motivated in the learning process. Based on the description above, the researcher concludes that mathematical self-efficacy is a person's belief or assessment of his or her own ability to solve certain mathematical problems or tasks related to mathematics.

A person's self-efficacy refers to three dimensions, namely magnitude, strength, and generality [29]. The magnitude dimension refers to students' confidence in their own ability to solve math problems and assignments with different difficulty levels. The strength dimension refers to the resilience and persistence of students in overcoming various kinds of math problems and tasks. The generality dimension refers to students' beliefs about their own ability to excel in certain mathematical activities as well as over a wider range of activities and situations. Students must have high self-efficacy so that they can support the success of the mathematics learning process and increase their achievement.

Self-efficacy can be developed through PBL. Several research results show this. Maulidia's research [30] concluded that the increase in the self-efficacy of students learning with the PBL model was better than the increase in the self-efficacy of students learning with conventional methods. Rahmawati [31], in her research, also concluded that the PBL E-Handout supported by the PhET simulation using Schoology could improve students' mathematical representation skills and self-efficacy. Furthermore, Anggalia's research [32] resulted in the conclusion that PBL is more effective than conventional learning when viewed from the ability to solve math problems and students' self-efficacy. From these studies, it can be seen that self-efficacy can be developed through PBL.

* 1. *The Relationship Between Problem-Based Learning Models Conducted Online and The Development of Student Self-efficacy*

In applying the PBL model, teachers help students to be able to develop thinking skills, problem-solving, intellectual skills, learn through real experiences, and become autonomous and independent learners. This can be seen from the steps in PBL which consists of five stages, namely the problem orientation stage, the stage of organizing students, the stage of investigating independently / in groups, the stage of developing and presenting work results, and the stage of analysis and evaluating the process [33].

At the problem orientation stage, students are faced with an authentic and meaningful problem. At this stage, the teacher helps students to reach a higher level of understanding. At the stage of organizing students, students are given the opportunity to develop their self-efficacy. At this stage, sources of self-efficacy are emphasized on aspects of authentic experiences, other people's experiences, and social approaches. At the stage of investigating independently / in groups, the teacher trains students to understand, clarify, choose solution strategies, and solve problems given independently or in groups. At the stage of developing and presenting work results, teachers train and accustom students to be able to collect data, dare to present answers obtained, and compare their answers with answers from other groups. In the analysis and evaluation stage, the teacher trains students to re-examine the answers they get and can draw conclusions from each lesson. At this stage, students who already have the correct answer will be more confident in their answers, while students who have the wrong answer will double-check their answers so that students will be even more careful.

Octaria's [34] experience in implementing PBL for lectures can add references to how PBL can develop student self-efficacy. At the first meeting, most students still found it difficult to follow lectures. During learning, students are invited to be actively involved in lectures by asking what difficulties they face. The lecturer sees to what extent the student's ability to work on the LKM is given and gives encouragement so that students are confident to display the answers from their group to be examined together. For every meeting, there is an increase in activity in the lecture process. Students are more enthusiastic about completing the given LKM. Students are not ashamed to ask questions when they face problems they don't understand. Students began to dare to appear to present their answers and be actively involved in the process of analyzing and evaluating both in groups and in-class discussions. In this way, the lecturer develops student self-efficacy.

The application of the Problem-based Learning (PBL) model, which is carried out online, as mentioned above, also uses five stages in its implementation. What distinguishes the online PBL model lies only in the media it delivers. If implemented properly, with careful preparation, including preparing students' abilities in using technology, theoretically, PBL, which is implemented online, will be able to develop student self-efficacy. The illustration for this is presented in Figure 1 below.

**Figure 1**. The relationship between the online PBL model and the development of student self-efficacy.

1. **Conclusions**

From the studies that have been done, the researcher concludes that theoretically, PBL, which is implemented online, has the potential to develop student self-efficacy. In principle, PBL steps carried out online are the same as PBL steps carried out offline. However, several things must be prepared properly by the teacher so that the PBL that is implemented can develop student self-efficacy. Including the important things that must be considered by teachers is the readiness of students, both from a technological and psychological perspective.

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