Potential Effect of Blended Problem-Based Learning to Support Students' Mathematics Activity

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Abstrak

Kurangnya aktivitas pembelajaran eksploratif yang melibatkan mahasiswa secara aktif masih menjadi masalah dalam pembelajaran matematika. Blended problem-based learning (BPBL), sebagai perluasan dari model problem-based learning (PBL), ditawarkan sebagai solusi alternatif untuk mengoptimalkan keterlibatan dan pengalaman belajar mahasiswa. Penelitian ini bertujuan untuk mengkaji aspek efektivitas produk perangkat BPBL berbasis LMS Moodle dalam menunjang aktivitas pembelajaran matematika. Menggunakan pendekatan kualitatif deskriptif, penelitian ini melibatkan 28 mahasiswa PGMI IAIN Bone, dengan fokus pada kriteria efektivitas produk terkait aktivitas belajar. Data efektivitas diperoleh melalui observasi, kuesioner, dan wawancara. Analisis data dilakukan secara kuantitatif deskriptif dan kualitatif dengan tahapan reduksi data, penyajian, dan penarikan kesimpulan. Hasil analisis menunjukkan bahwa BPBL berkontribusi positif terhadap keaktifan mahasiswa, baik dalam pembelajaran tatap muka maupun pada pembelajaran online. Keaktifan mahasiswa pada aktivitas fisik seperti aktivitas lisan, menulis, visual, dan motorik memenuhi kriteria tinggi. Hasil penelitian juga mengindikasikan adanya efek potensial produk yang positif pada aktivitas emosional dan mental. BPBL cukup efektif dalam menstimulasi ketertarikan, motivasi dan kemandirian belajar serta mampu memfasilitasi interaksi dan kolaborasi dalam pembelajaran.
Kata Kunci: Aktivitas mahasiswa; BPBL; Keefektifan; Pembelajaran matematika.

Abstract

The lack of explorative learning activities that actively involve students remains problematic in mathematics education. BPBL, as an extension of PBL model, is proposed as an alternative solution to optimize student engagement and learning experience. This study aims to investigate the effectiveness of BPBL using the Moodle LMS in mathematics

learning. This is a descriptive qualitative study involving 28 PGMI IAIN Bone students. Effectiveness criteria focus on potential effects related to student activities, with data gathered from observations, questionnaires, and interviews. Data were analyzed quantitatively and qualitatively, including data reduction, presentation, and conclusion drawing. The major finding indicates that BPBL positively contributed on students' activeness in both face-to-face and online learning. The students' physical activeness in oral, writing, visual and motor activities were in high category. The finding also reveals other potential effects of product such as in emotional and mental activities. BPBL was considerably effective to stimulate students' motivation, self-paced learning as well as facilitate interaction and learning collaboration.

Keywords: BPBL; effective; mathematics learning; students' activity.

I. INTRODUCTION

The essence of a learning activity is not merely the delivery of learning content by educators to students. Beyond that, the learning activities should facilitate active knowledge construction by students, develop their thinking skills, and encourage them to apply the formal knowledge they acquire in solving real-world problems (Zaneta, 2022). This aligns with one of the focuses of 21st-century education, which is to present meaningful learning experiences that can be applied in solving real-world issues (Alismail & McGuire, 2015; Muzaki & Masjudin, 2019).

One of the learning models that educators can use to address this challenge is problem-based learning (PBL). PBL is an innovative active learning model that is learner-centered (Barth, 2019; Catz, 2018) and emphasizes the use of authentic problems as the starting point of the learning process (Arends, 2013; Afriansyah, 2022).

Numerous research studies have explored the positive impacts of implementing PBL, particularly in mathematics education (Farida et al., 2019). PBL not only enhances students' conceptual understanding and learning outcomes (Fauzia, 2018; Kamid, Anggaraeni & Muhtadin, 2018) but also promotes active learning, improves higher-order thinking skills, develops critical thinking, problem-solving abilities, and fosters collaboration and effective communication among students (Abrami et al., 2015; Moallem, 2019; Muller et al., 2017; Wilder, 2015).

While PBL offers many advantages, its implementation may present some challenges, such as time constraints (Lukitasari et al., 2019). PBL is claimed to require relatively more time (Blackwell & Roseth, 2018) compared to conventional teacher-centered learning (Marta, 2011). In this regard, teachers need to possess time management skills and prepare well-designed learning scenarios. Alternatively, PBL can be incorporated in a blended learning format, which combines face-to-face and online learning.

Blended learning is an innovative form of internet-based learning (e-learning) that integrates face-to-face and online learning (Darma et al., 2020). Blended learning has been widely applied in Indonesian higher education institutions and offers numerous advantages (Zainuddin & Keumala, 2018). To support its implementation, Learning Management Systems (LMS) are commonly used to manage online learning in blended learning models (Holmes & Prieto-Rodriguez, 2018; Kabassi et al., 2016)). LMS is a software package with various features that support the execution and management of learning activities (Edmunds & Hartnett, 2011; Wirawan & Mukid, 2018), and one of the popular LMS platforms is Moodle.

Integrating PBL into the blended learning model, often referred to as blended problem-based learning (BPBL), is an effort to combine the strengths of both models while incorporating technology without eliminating face-to-face interaction. In various studies, the implementation of BPBL has shown many positive impacts on student learning

activities, such as effectively training thinking skills (Ibrahim, 2018; Reilly, 2019), including critical thinking abilities (Arohmatul & Sumarni, 2019; Lukitasari et al., 2019), increasing motivation and active engagement (Donnelly, 2017), enhancing self-directed knowledge construction (Shimizu et al., 2019), and facilitating more active and effective learning (Triyanto & Prabowo, 2020).

An ideal learning experience is learner-centered, emphasizing student engagement through various learning activities designed by the instructor as a facilitator (Khan et al., 2017). However, the lack of explorative learning activities that actively involve students remains problematic in mathematics education. This challenge is also evident in the implementation of mathematics education at SD level within the PGMI program at IAIN Bone. Preliminary findings indicate that students' engagement in learning activities has not been maximized. This is evident from their limited initiative in actively participating in the learning process, such as expressing opinions, critical thinking, and generating ideas in problem-solving.

Another challenge is the time constraint. Based on interviews, SRD and FU (PGMI students) admitted that they sometimes struggle to grasp a large amount of material within a short time during classroom meetings. They feel that they need more time to solidify their understanding of the subject matter. This aligns with the acknowledgment of Z (lecturer of mathematics course in PGMI) that the allocation of face-to-face learning time is not ideal for exploring various learning activities that can optimize students' engagement.

Reflecting on these conditions, BPBL becomes an alternative solution believed to bring about a more flexible learning experience that optimizes student engagement. With the strengths offered by both PBL and blended learning models, their integration is expected to enhance student engagement, foster self-directed learning, and facilitate the construction of knowledge through meaningful and enjoyable learning activities.

There have been numerous previous studies on PBL and blended learning separately. However, research on the combination of the two, specifically BPBL, is still relatively limited. Moreover, there is no specific research yet that examines the effectiveness of BPBL in mathematics education, particularly regarding student engagement. Therefore, this study aims to investigate the effectiveness of the BPBL tool based on Moodle LMS in supporting mathematics education learning activities.

II. METHOD

This study is descriptive research with a qualitative approach involving 28 students from the PGMI program at IAIN Bone. The main objective of this study is to analyze the effectiveness of the developed BPBL product in supporting mathematics education learning activities. Specifically, the BPBL product refers to the integration of problem-based learning into the blended learning model based on Moodle LMS, focusing on the topics of LCM (Least Common Multiple) and GCD (Greatest Common Divisor) in elementary school mathematics courses.

Data for this study were collected through observation, questionnaires, and interviews. Data validity was ensured through data triangulation, utilizing various methods and sources to obtain data. The students' learning activities were observed through participatory observation, which focused on four categories of learning activities: oral, visual, writing, and motor activities. This categorization is based on Paul B. Diedrich's classification of learning activities, which includes eight types: oral, visual, listening, writing, drawing, motor, mental, and emotional activities (Hamalik, 2015). However, for the purpose of this study, the observation was limited to physical activities, namely oral, visual, writing, and motor activities. The observation covered both face-to-face and online learning settings. The data collected from the observations were then presented in percentages and classified based on the criteria of activity levels outlined in Table 1.

Table 1.
Criteria for Students' Activeness

No	Performance (%)	Categories
1	75 – 100	High
2	51 – 74	Medium
3	25 – 50	Low
4	0 – 24	Very low

An open-ended questionnaire was used to gather data on students' responses regarding the effectiveness of the BPBL product. The questionnaire included questions covering aspects such as motivation, self-directed learning, interaction and collaboration, as well as the usefulness of the product in enhancing cognitive abilities. Furthermore, interviews were conducted with five randomly selected students to obtain more in-depth information regarding the effectiveness of the BPBL product concerning students' learning activities. Data analysis was carried out qualitatively through three stages: data reduction, data presentation, and drawing conclusions, following the approach outlined by (Huberman & Miles, 2019).

III. RESULT AND DISCUSSION

The Moodle-based BPBL (Figure 1) being evaluated for its effectiveness comprises a series of face-to-face and online learning activities. The BPBL learning activity scenarios are designed by considering the PBL syntax as well as the main dimensions and characteristics of blended learning, as outlined in the theory of "five key ingredients" proposed by Carman (2002) which include live events, self-paced learning, collaboration, assessment, and performance support materials.

Figure 1. Product of BPBL Moodle

Effectiveness is one of the three criteria that need to be evaluated for a development product (Nieveen, 1999). The focus of assessing the effectiveness of the product in this article is limited to the potential effects of the BPBL product as a support for students' learning activities.

A learning development product is considered effective if it helps students achieve the competencies they need. In his study, (Cahyadi, 2019) stated that the affective aspect can be observed through students' acceptance attitudes towards the learning activities and their increased abilities as a result of using the product in the learning process.

One aspect of effectiveness is the expected effectiveness, commonly referred to as having potential effects (Plomp & Nieveen, 2007). Furthermore, a product is considered to meet the aspect of effectiveness (having potential effects) if experts, practitioners, and users (lecturers and students) based on their experience feel the benefits as potential effects of the developed product related to students' activeness during the learning process.

Based on the observation results, the learning scenarios included in the BPBL provide opportunities for students to take an active role in their learning. The observed learning activities of students include oral activities, writing activities, visual activities, and motor activities.

Table 2.
Observation Result of Students' Activeness

No	Activities	Performance (%)	Categories
1	Oral	78	High
2	Motor	84	High
3	Writing	81	High
4	Visual	80	High
	Average	80,75	High

Table 2 shows that the average percentage of student activities in the four categories of physical activities falls under the high category. These results indicate that students have demonstrated active engagement in learning activities, both in face-to-face and online learning.

In more detail, out of the four types of observed physical activities, motor activity is the one with the highest percentage of occurrence in the learning process. In this regard, students demonstrate excellent activeness in several motor activities during face-to-face learning, such as playing "happy boom" and clapping in groups to understand concepts of multiples, common multiples, and LCM. Another motor activity involves the experiment of arranging unit square papers to explore the concept of factors and common factors.

Students also show high activeness percentages in the other three activities (Table 2): oral (78%), writing (81%), and visual (80%) activities. The observed oral activity during face-to-face learning includes questioning, expressing opinions, discussing, and presenting group discussion results. Students are organized into small groups to discuss and solve contextual problems given. They are encouraged to exchange ideas, present arguments, and orally present their group discussion results. However, these oral activities can only be observed directly during face-to-face learning.

On the other hand, writing activities can be observed in both face-to-face and online learning. During face-to-face learning, observed writing activities include writing down problem-solving strategies, either individually or in groups. Meanwhile, during online activities, students engage in writing activities when answering quizzes and completing practice questions accessible on the Moodle platform.

Online learning activities also involve visual activities, including reading announcements and learning instructions,

contextual problems, and practice questions provided for each sub-topic, as well as watching instructional videos available on the Moodle platform. In face-to-face learning, visual activities are observed when students pay attention to the material presented by the lecturer, both through direct instruction and PowerPoint presentations.

During face-to-face sessions, most students actively participate in experiments, games, problem-solving, presenting arguments, and discussions. In online activities, students engage in various activities, such as reading contextual problems and devising problem-solving strategies, taking quizzes, participating in online discussions, reading handouts, watching videos, and completing practice questions on the Moodle platform.

Data related to the four observed physical activities was undertaken through observation techniques. Non-physical activities such as mental and emotional activities were obtained through questionnaires and interviews. The results of the student response questionnaire based on the four measured aspects show an average percentage in the high category (Table 3). This indicates that students provide positive responses to the implementation of BPBL.

Table 3.
Questionnaire Result of Students' Responses

No	Aspect	Performance (%)	Categories
1	Motivation	82	High
2	Independent learning	88	High
3	Interaction	79	High
4	Cognitive	80	High
	Average	82,25	High

The questionnaire results indicate that BPBL is considered to have a positive effect in several aspects, including helping in the development of students' cognitive abilities. This is related to mental activities such as problem-solving, devising problem-solving strategies, analyzing contextual problems given at the beginning of each sub-topic, and drawing conclusions.

The interview results support this, as three out of five informants (MH, F, AM) stated that the BPBL activities engaged them actively in the learning process. They were encouraged to think, analyze, and devise problem-solving strategies since there were contextual problems that needed to be solved at the beginning of each sub-topic. Students admitted that they found these problems challenging, although sometimes difficult to solve.

The findings from the questionnaire and interviews also indicate positive emotional responses from students, showing interest, enthusiasm, and motivation in participating in BPBL-based learning. One informant stated their interest in the following interview excerpt:

SAB: "*Very interesting, especially the games and practical activities in the classroom. The online learning is also great. I can watch the videos multiple times until I completely understand. The animated videos are captivating. Besides, there are online quizzes. We can see our ranking when answering them. It makes us more motivated.*"

The learning scenarios comprising various activities are acknowledged to increase students' interest and motivation in learning. Games and experiments are

considered the most enjoyable activities by most students. Moodle-based online learning, which provides abundant learning resources, also makes students more enthusiastic about learning. Obstacles such as understanding the lecturer's explanations in class and limited class time can be overcome through online activities.

Students find it easy to revisit and review materials they have difficulty understanding by downloading handouts and rewatching instructional videos. Students with lower cognitive abilities in mathematics also admit that the online learning system in BPBL has been very helpful. They feel more motivated and no longer feel inadequate in mathematics. They have the opportunity to review and study the materials more extensively.

The learning activities with BPBL are perceived to be more organized. Students regularly monitor their Moodle accounts, read announcements, solve contextual problems at the beginning of each sub-topic, prepare the material they will study in class, and complete quizzes and exercises with flexible timings. Easy access to learning resources is also positively perceived by students. Accessing learning materials anytime and anywhere is considered very convenient for students.

In general, the interview and observation results show that students' activeness in physical activities such as oral, visual, writing, and motor activities, both in face-to-face and online learning, meets high criteria. This is evident from the diverse activities in which students actively and effectively explored during the learning process, both physically and non-physically.

These findings indicate that the BPBL scenario comprising various activities stimulates students to actively engage in the learning process. All interviewed students agreed that they were conditioned to be more active in their learning. This is because the sequence of activities in the five learning units (both online and face-to-face) provided them with opportunities to be directly involved in various activities that demand activeness in exploring their own knowledge.

The learning activities are student-centered, starting by orienting students to authentic and contextual problems, then actively guiding them to identify and formulate problems, study and search for relevant materials, present discussion results, and conclude and evaluate problem-solving. These activities align with the main characteristics and syntax of PBL (Arends, 2013). Based on the observations, the PBL syntax integrated into blended learning encourages students to actively engage in learning, both physically and non-physically. Previous studies (Arsyad, 2019; Mutmainnah & Nurfalah, 2019; Sochib, 2020) also support these findings, showing that PBL can increase mathematics learning activities.

The sequence of activities makes mathematics learning more meaningful and helps students in deeper understanding of the material. This aligns with previous studies stating that BPBL improves students' understanding of the material (Donnelly, 2017; Triyanto & Prabowo, 2020). BPBL can also enhance students' higher-order cognitive skills (Ibrahim, 2018) (M. Ibrahim et al., 2015)

such as critical thinking and reasoning (Arohmatul & Sumarni, 2019).

Training higher-order thinking skills is one of the potential effects of BPBL found in this research. Although the results are not yet optimal, students admit that various BPBL activities stimulate their mental activities, such as problem-solving skills. They are trained to think critically in analyzing and devising problem-solving strategies for authentic contextual problems given at the beginning of the learning process. This aligns with previous studies that contextual problems in PBL can train students' mathematical problem-solving skills (Moallem, 2019; Novianti et al., 2019; Reski et al., 2019).

The questionnaire and interview responses also show that BPBL has aroused students' interest and motivation in learning. Almost all students feel motivated, interested, and more enthusiastic to learn mathematics through BPBL compared to conventional face-to-face learning they had been doing. This strengthens the findings of Donnelly (2017) that BPBL effectively increases students' motivation and learning activeness.

Motor activities are among the most favored activities and are considered highly effective in stimulating students' activeness. Games, demonstrations, and experiments are examples of motor activities that can encourage student engagement. Students are encouraged to conduct experiments and investigations, which eventually lead them to discover concepts and construct ideas independently. Motor activities provide meaningful and enjoyable learning experiences through the principle of learning by doing. These results align with previous studies (Celik, 2018) that inquiry-based learning or other physical activities can enhance students' learning activities.

The learning experience using BPBL Moodle also receives positive responses regarding the usability and accessibility of Moodle as an online medium. E-learning as a component of the developed product is believed to facilitate students' learning. It enables students to revisit materials they have difficulty understanding during face-to-face learning and provides easy access to various learning resources.

Students can access the Moodle LMS platform online anytime and anywhere. They are free to rewatch instructional videos to solidify the material studied in class, download handouts, and complete practice questions and quizzes available. The questionnaire results also show that all students have the opportunity to complete more practice outside the classroom.

Moreover, the implementation of blended learning ensures that all materials are presented comprehensively without being constrained by limited face-to-face class time. In other words, BPBL ensures that all learning materials can be conveyed thoroughly. This solves the problem students faced in the past, where the limited face-to-face class time for mathematics subjects made it challenging to comprehensively understand all the materials taught.

Another potential effect is that BPBL enables broader collaboration and interaction. The interaction occurs not only in the classroom but also outside it in a

more flexible manner. In BPBL, students actively utilize the discussion feature through the discussion forum. Through this feature, students have enough space to engage in virtual interactions such as discussions related to the learned material. The discussion forum is not solely controlled by the teacher; it is open and can be used by all students at any time and anywhere. This aligns with the collaboration principle, one of the main keys of blended learning (Carman, 2002).

This aspect of interaction and collaboration is in line with what Donnelly (2017) stated that BPBL can increase student interactions in the learning process. The selection of authentic tasks in PBL and the process of solving problems together require students to expand collaborative dialogues both online and face-to-face, resulting in more effective learning. In other words, BPBL can enhance the interaction between teachers and students in collaborative learning (Lin et al., 2017), enabling students to learn more actively and effectively.

Another beneficial aspect that serves as a potential effect in this research is that BPBL facilitates students to learn independently. This self-paced learning is also one of the main keys of blended learning (Carman, 2002). The questionnaire and interview data show that all students agree that the implementation of BPBL effectively helps them in independent learning anytime and anywhere. This finding supports the previous study, stating that BPBL positively contributes to helping students become active and independent learners (Shimizu et al., 2019).

Through BPBL, students can utilize available learning resources without being entirely dependent on face-to-face class materials from the teacher. Gebre et al. (2014) also stated that blended learning plays a role in creating student-centered learning, where students are encouraged to learn actively and independently without always depending on teachers as information and knowledge providers.

IV. CONCLUSION

The analysis of the effectiveness of Moodle-based BPBL product indicates that BPBL significantly contributes to students' active learning engagement, both in face-to-face and online settings. The diverse learning scenarios effectively encourage students to be actively involved in the learning, both physically and cognitively.

The research findings reveal that oral, writing, visual, and motor activities are well explored and successfully stimulate student engagement. Particularly, motor activities have shown great potential in fostering students' participation and involvement in the learning process. Moreover, the study suggests a positive potential effect of BPBL on students' emotional and cognitive activities. BPBL proves to be effective in generating interest, motivation, and self-directed learning among students while facilitating interactions and collaboration within the learning environment. In conclusion, the BPBL product meets the criteria for effectively enhancing students' activities in learning mathematics.

However, it's important to note that this research solely focused on analyzing the aspect of students' activity and engagement in learning. Future studies

should explore the effectiveness of BPBL in achieving cognitive outcomes in mathematics learning. Considering the numerous potential benefits offered by BPBL, it is hoped that the product can be more broadly implemented across different courses with relevant adjustments to suit various contexts. By doing so, BPBL can provide broader advantages in learning across different subjects and educational settings.

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