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Blended Learning for Developing Problem-solving Skill, Learning Motivation, and Student Engagement in Mathematical Physics II Course During the COVID-19 Pandemic

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Abstract.
This study aimed to identify the effects of teaching Mathematical Physics II (FIS1221) through blended learning during the COVID-19 pandemic on problem-solving skills, learning motivation, and student engagement at Ganesha University. The study followed a pre-experimental approach. The research subjects consisted of 27 fourth-semester students. The pre- and post-test data on the problem-solving ability were collected through a problem-solving test, while the learning motivation data were gathered using a questionnaire. Data on learning engagement were collected only post-test using a questionnaire. Data analysis was done descriptively, and *t*-test was used for analysing the problem-solving ability and learning motivation. Additionally, data on learning engagement were analyzed using the Wilcoxon Signed Rank Test. The results showed (1) a significant difference between the average score of the pre- and post-test problem-solving abilities; (2) a significant difference between the average score of the pre- and post-test learning motivation; and (3) a difference in student engagement scores with standard scores specified (a passing grade). Therefore, blended learning is an effective approach for developing problem-solving skills, learning motivation, and student engagement.

Keywords: blended learning, problem-solving skill, learning motivation, student engagement

1. Introduction

The Mathematical Physics II (FIS1221) course aims to give a mathematical foundation for advanced physics courses such as mechanics, magnetic electricity, optical waves, quantum physics, statistical physics, and solid matter. This course is taught face-to-face in class. However, during the pandemic, the Indonesian government since March 2020 has set a policy of Large-Scale Social Restrictions (PSPB). This policy has a direct impact on the practice of providing education at all levels. Learning that was originally dominantly carried out face-to-face in class, immediately turned into online lectures and was replaced with online lectures. In online learning, learning is more controlled by students. Judging from the characteristics of the content of Mathematical Physics II, not all materials can be studied independently, there are many materials that still need direct guidance from the lecturer. Therefore, it is necessary to have alternative learning methods that are more flexible that offer opportunities for students to regulate and control their own learning, but still offer opportunities for direct student-learners and/or learner-teacher interactions to foster social relationships and provide direct guidance.

Sophisticated network systems have led to a revolution in education that allows the application of alternative learning methods ”anytime and anywhere” for online learners around the world [1], providing learning opportunities with various digital devices [2], controlling learning speed, information flow, and activity selection and time management [3]. Behind the advantages of online learning there are disadvantages related to video-based content design, teleconferencing, and limitations. bandwidth and social problems such as loss of direct interaction. Starting from the advantages and disadvantages of face-to-face and online lectures, educators have developed blended learning methods.

In general, blended learning is defined as a combination of face-to-face learning methods with asynchronous and/or synchronous computer technology [4]. In developing the right blended learning format, the face-to-face learning syllabus must be redesigned to include both face-to-face and online content [5]. Blended learning is a solution for teachers who want to promote active, independent, and flexible learning opportunities [6]. During the COVID-19 pandemic, blended learning was an alternative that could be applied in teaching various courses at school and universities [7], [8]. Blended learning is expected to develop problem solving skills, learning motivation, and student engagement.

1.1. Problem Solving Skill

Problem solving skills are one of the targets of teaching mathematical physics. Problem solving and critical analysis skills are competencies that must be developed by students before graduating from college [9] (Barrie, 2006). In mathematics, Polya [10] (available at [https://math.berkeley.edu/~gmelvin/polya.pdf) states that the best way to understand mathematical concepts is through problem solving. In the field of physics to be able to solve problems requires a deep understanding of the basic concepts of physics, including their use in certain situations [11]. The correct solution indicates the correct concept and the interconnection of ideas related to the problem situation. Furthermore, Heller & Anderson [11] suggest a problem-solving strategy consisting of five stages, namely: visualizing the problem, physical description), plan a solution), executing the plan, and evaluate the solution). This model is suitable to be applied in solving problems in mathematical physics, because mathematical physics basically examines physical phenomena that are modeled in mathematical equations/formulas.

1.2. Learning Motivation

Motivation is a process that gives enthusiasm, direction, and persistence of behavior [12], a desire or willingness to do something [13], a condition of eagerness to act or work, a force or influence that causes someone to do something [14]. Learning motivation is a condition that exists in a person where there is an urge to do something in order to achieve individual goals. In teaching and learning activities, motivation and learning are closely related because each learning activity is influenced and preceded by motivation arising from individuals or influences from outside the individual. Several motivational ideas that are important and related to students' learning motivation in learning physics, namely: 1) intrinsic and extrinsic motivation, 2) direction of goals (goal orientation), 3) responsibility (self-determination), 4) self-efficacy, and 5) anxiety about judgment.

1.3. Student Engagement

Student engagement is a multidimensional construct that is influenced by the interaction of various complex influences and factors [15]. Student engagement appears to be the cornerstone of high-quality education and is associated with academic success [16], favorable educational outcomes [17], and student satisfaction [18]. Whichever learning mode is used (face-to-face, mixed, or virtual), student engagement is characterized by enthusiasm, interest, sense of belonging [19], [16], [20], deep learning [16], self-regulation, time and effort invested in learning, interaction and participation [16], [18], feelings of autonomy, and choice and control [15], [16]. Thus, it can be seen that student engagement is a multidimensional construction consisting of these characteristics.

Several researchers (such as [5] Wichadee, 2011; [21], [22], [23] have demonstrated the effectiveness of Blended Learning in developing engagement, motivation, learning outcomes, positive attitudes. and the level of student satisfaction. The evidence of the effectiveness of blended learning as above, is enough to be used as a reference to apply the blended learning method in Mathematics II physics learning by making modifications to make it visible during the covid-19 pandemic. Modifications were made by replacing face-to-face in class with face-to-face online through various services such as Zoom, Google Meet, Microsoft Team, WebEX, CloudX and others. With this modification, student-teacher interaction can still occur.

This study aims to analyze the effectiveness of Modified Blended Learning in building student engagement, increasing learning motivation, and improving problem solving skills in Mathematics II teaching.

2. Method

2.1. Research Subject

The subjects of this study were fourth semester students of the Physics Education Study Program, Faculty of Mathematics and Natural Sciences, Ganesha University of Education. The number of subjects is 27 people who are divided into two classes, namely class A 12 people and class B 15 people

2.2. Data Collection Techniques

The data collected in this research are problem solving skill, learning motivation, and student engagement. Data on the problem-solving skill of mathematical physics II was collected by means of a problem-solving test that was scored with a problem-solving assessment rubric covering the following aspects: problem visualization), physics description, solution plan a solution), execute the plan), and evaluate the solution).

Data on learning motivation were collected using a learning motivation questionnaire. This motivation questionnaire was developed from aspects of learning motivation which includes 1) intrinsic and extrinsic motivation, 2) goal orientation), 3) self-determination, 4) self-efficacy), and 5)anxiety. The learning motivation questionnaire consists of statement items with 5 alternative answer choices, namely: Strongly Agree, Agree, Moderately Agree, Disagree, Strongly Disagree. Data on learning engagement were also collected with a learning engagement questionnaire. Aspects that will be measured related to engagement includes: enthusiasm, interest, sense of belonging, self-regulation, time and effort invested in learning, interaction, and participation, feelings of autonomy, choice, and control.

2.3. Data analysis technique

Data on problem solving skills, learning motivation, were analyzed using descriptive and inferential statistical techniques. Qualifications of problem-solving skill, learning motivation, and student engagement were categorized into very high, high, medium, low, and very low levels. This category refers to guidelines such as table 1.

TABLE 1: Criteria for problem solving skill, learning motivation, and student engagement category.

Avarage Score	Category
85 - 100	Very High
70 - 84	High
55 - 69	Medium
45 - 54	Low
< 45	Very low

3. Results

3.1. Descriptive Statistic

3.1.1. Problem solving skill

Measurement of problem solving skill was carried out twice, namely before learning (pre-test) and after learning (post-test). The average pre-test and post-test are shown in Table 2.

TABLE 2: Descriptive Analysis Of PSS.

PSS	N	Min	Max	Mean	SD
PRE-TEST	27	45.00	80.00	62.67	9.54
POST-TEST	27	70.00	83.30	78.35	3.62

As shown in table 2, the pre-test score of students' problem-solving skill before ranged from 45.00 (minimum) to 80.00 (maximum) with an average pre-test score $\overline{X}$ = 62.67 (SD = 9.54) which is included in the medium category. Meanwhile, the post-test score-solving skill ranged from 70.00 (minimum) to 83.30 (maximum), with an average of $\overline{X}$ =78.35 (SD=3.62). There appears to be an increase in the average score from pre-test to post-test of 15.68 points.

3.1.2. Student Learning Motivation

As in problem solving skills, the measurement of student learning motivation (LM) is also carried out in two stages, namely before learning (pre-test) and after learning (post-test). Table 3 shows a summary of descriptive results of learning motivation scores on the pre-test and post-test.

TABLE 3: Descriptive analysis of learning motivation.

Learning motivation	N	Min	Max	Mean	SD
Pre-test	27	56.00	80.00	68.00	5.02
Post-test	27	57.84	84.32	71.81	5.24

In general, the pre-test scores for students' learning motivation ranged from 56.00 (minimum) to 80.00 (maximum). The average pre-test score was X =68.00 (SD=5.02) included in the medium category. The post-test scores of students' learning motivation ranged from 57.84 (minimum) to 84.32 (maximum). The post-test mean score was $\overline{X}$ =71.81 (SD5.24), which was included in the high category. There is an increase in the average score from pre-test to post-test 3.81 points.

3.1.3. Student Engagement

Measurement of student engagement is only measured at post-test. This is because student engagement starts from ongoing learning and continues to process, so there is no initial engagement. Student engagement scores ranged from 62.50 (minimum) to 90.83 (maximum). The average student engagement score is $\overline{X}$ = 80.25 (SD = 7.52) which is included in the high category. When compared with passing grade score = 75.00, the average student engagement score is higher than the passing grade.

3.2. Inferential and Nonparametric Statistic

3.2.1. Problem Solving Skill (PSS)

The effectiveness of Blended Learning on motivation and problem-solving skill was tested by inferential statistics, namely t test for related samples. Before the t test is carried out, a prerequisite test is carried out, namely the normality test of the data distribution with the One-Sample Kolmogorov-Smirnov Test.

The pre-test statistic test value is 0.128 with sig. p=0,200,0.05. Meanwhile, the statistical test score for the posttest was 0.157 with sig p=0.085 >0.05. Starting from these results, it can be stated that the pre-test and post-test scores of students' problem-solving skill were normally distributed.

To test the difference in the mean scores of pre-test and post-test of students' problem-solving skill, the t-test was used. Table 4.5 shows a summary of the results of the t-test the difference in the average scores per-test and post-test.

Table 4: Problem solving Skills t-test summary.

		Levene's Test for Equality of Variances					
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Problem-Solving Skill	Equal variances assumed	26.841	.000	-7.980	52	.000	-15.67963
	Equal variances not assumed			-7.980	33.347	.000	-15.67963

As shown in table 4.5, Levene's Test for Equality of Variances shows a value of F = 26,841 p<0.05). This shows that the variance of the per-test score and post-test score is not homogeneous. Therefore, the result of the t-test used is the t-value based on the assumption of unequal variances. The value of t with the assumption of unequal variance is t=-7.980, with p<0.05. This shows that there is a difference in the average score of students' problem-solving skill between the pre-test and post-test, where the post-test average score is greater than the pre-test with a difference of 15, 68. It can be stated that the modified Blended Learning effective in improving students' problem-solving skills.

3.2.2. Learning Motivation

The effectiveness of Blended Learning in increasing students' learning motivation was tested by comparing the average per-test and post-test scores. This comparison test is done by t test. But previously tested for the normality of the distribution of pre-test and post-test scores using the One-Sample Kolmogorov-Smirnov Test. The Kolmogorov-Smirnov statistical value of the pre-test score was 0.139, p>0.05, while for the post-test the was 0.151, p>0.05. These data indicate that both the pre-test and post-test scores are both normally distributed. As shown in table 5, the t-value of the average difference between the pre-test and post-test scores are t=-2.729, p<0.05.

Table 5: The summary of t-test pre-test, post-test score learning motivation

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference
LM	Equal variances assumed	.004	.953	-2.729	52	.009	-3.81
	Equal variances not assumed			-2.729	51.909	.009	-3.81

This shows that there is a significant difference in the average pre-test and post-test scores of learning motivation skill. The average posttest score is greater than the pre-test with a difference of 3.81 points. So, modified Belnded Learning is effective in increasing student learning motivation.

3.2.3. Student Engagement (SE)

The effectiveness of Bended Learning in developing student engagement was tested by comparing the student engagement score with the passing grade score, namely 75.00. Wilcoxon Signed Test was used to comparing student engagement scores to the passing grade score. Table 6 shows the Mean Rank of passing grade score minus engagement score is 12.93 and the mean rank for positive ranks is 13.38. Wilcoxon's statistical test showed Z=2,936, p<0.05. This fact shows that there is a difference between students' engagement scores and the passing grade score. In other words, Blended Learning is effective in developing student engagement. Average score of students' engagement was higher than passing grade.

Table 6: The summary of Wilcoxon Signed Test students' engagement scores.

		N	Mean Rank	Sum of Ranks	Statiscs	KKM-ENG
KKM - ENG	Negative Ranks	21^a	12.93	271.50	z	$-2{,}936^a$
	Positive Ranks	4^b	13.38	53.50	Asymp. Sig (2-tailed)	0,003
	Ties	2^c			a.Wilcoxon Signed Test	
	Total	27			b. Based on positive ranks	

4. Discussion

The purpose of this study is to develop problem-solving skills, learning motivation, and student learning involvement through the application of Modified Blended Learning in learning during the COVID-19 pandemic. The application of Blended Learning is carried out in two effective two months of effective Mathematical Physics II learning which consists of 6 meetings, where each meeting takes place in 3x50 minutes. Learning is done online, either synchronously or asynchronously. The effectiveness of Blended learning in developing problem-solving skills and learning motivation is measured by comparing the average pre-test score and the average post-test average score. Meanwhile, the measurement of the effectiveness of Modified Blended Learning in developing student engagement is measured by comparing the average post-test score to the passing grade score.

The results showed that the average score of students' problem-solving skills after the application of Modified Blended Learning was $\overline{X}$ =78.35 (SD=3.62), included in the high category. While the average score of problem solving before learning is $\overline{X}$ = 62.67 (SD = 9.54) which is included in the medium category. The average problem-solving score after learning is greater than before learning with an increasing of 15.68 points. The t-test showed that there was a significant difference in the average problem-solving ability scores of students before and after learning (t=-7,980; $p<0.05$). This means that the application of Modified Blended Learning is effective in building students' problem-solving skill in Mathematical Physics II teaching.

The results of this study support the results of previous studies on the effectiveness of Blended Learning in developing problem-solving skill [24], [22], and [25]. In the application of modified blended learning, students are given ample opportunity to organize their own learning according to their capacity. The parts of the subject matter assigned to be studied alone, both offline and online, are determined jointly by the teacher and students. Students are given the freedom to choose the part of the material that they think can be learned independently. Other parts are discussed in face-to-face activities. To ensure that students really learn the part independently or together with their colleagues, they are required to solve problems/problems related to the part of the material being studied. Troubleshooting results are uploaded in the LMS. In a face-to-face session, if the teacher finds an imperfection in student work, it has been discussed first before discussing the material taught face-to-face. In blended learning students are given regular problem-solving exercises. This can be seen why blended learning is able to develop problem solving skills at a high level.

In addition to developing problem-solving skills, this study also found that modified Blended Learning was also effective in developing students' learning motivation. Students' learning motivation after learning through blended learning was significantly different from before learning ($t=-2.729$, $p<0.05$). The results of this study support previous studies which revealed that blended learning is effective for increasing students' learning motivation [26], [27], [28] , [23]. In blended learning, the teacher provides reinforcement for every task that students do online, both individually and in groups. Positive reinforcement received by students on work will increase their learning motivation. Increased motivation will increase the level of learner involvement in learning. In modified blended learning, students have the opportunity to interact directly with teachers through face-to-face online. So educational touches can still be felt by students and this can increase their learning motivation. This opportunity is mostly used by teachers to guide and motivate students. Students' learning motivation affects their learning outcomes.

Student engagement is very important role in learning. Learning engagement is related to the applied learning model. This study also shows coherence with this concept. The results of this study also show that blended learning is effective in developing student learning engagement. Blended learning can develop students' learning involvement in mathematical physics II at a high level. The effectiveness of modified blended learning in developing learning engagement found in this study is in agreement with several previous studies, [29], [21]. Blended learning provides opportunities for students to organize their own learning.

In blended learning, some of the tasks that are usually taught by the teacher, are studied by the students themselves. They are facilitated with various learning resources such as modules, textbooks, learning videos, and power points. To guide them to study the teacher provides the bills they must meet. During the COVID-19 pandemic, students learn through networks, both synchronously and asynchronously. Students can consult with teachers online when they find problems in self-study. Thus the interaction of teachers and students continues. The existence of a portion of material that must be studied by students can increase their responsibility and involvement in learning.

In blended learning, there is a combination of face-to-face virtual activities and interactive online activities. The combination of face-to-face and interactive online elements can empower students to control their learning and will have a positive impact on content understanding [29]. The high involvement of students in learning has a positive impact on learning outcomes. Several elements of the online environment are designed to enhance interaction among learners and between learners and teachers.

Engaged learners can increase interaction between learners, learners and materials, as well as learners and teachers. The frequency of online interactive forums by students positively correlates with student performance.

5. Conclusion

In conditions of the COVID-19 pandemic, which does not allow direct face-to-face learning in class, the application of modified blended learning is an effective alternative to developing students' skill to master the course material, their learning motivation, and their learning involvement in mathematical physics II courses. Modified blended learning is blended learning that is adapted to the conditions of Covid-19, where face-to-face is directly replaced by virtual face-to-face.

The implementation of modified blended learning in mathematical physics class II concludes; (1) there is a significant difference in the average score of students' problem-solving skill and learning motivation between before and after learning; (2) there is a significant difference in student engagement score to the passing grade score. The average score of problem-solving skill and learning motivation after learning is higher than before learning. The average student engagement score is higher than the passing grade score. Modified blended learning is effective in developing student problem-solving skill, learning motivation, and student engagement in mathematical physics II course.

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