Berkala Ilmiah Pendidikan Fisika
ISSN : 2337-604X (print)
ISSN : 2549-2764 (online)

Vol 10 No 1 2022
https://ppjp.ulm.ac.id/journal/index.php/bipf
page 126-134

Inquiry-based Blended Learning Design for Physics Course: The Effectiveness and Students' Satisfaction

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DOI:10.20527/bipf.v10i1.12468

Received: 12 January 2022 **Accepted: 11 May 2022** **Published: 22 May 2022**

Abstract

This paper describes the effects of implementing inquiry-based blended learning (IBBL) design on students' learning achievement and satisfaction in an undergraduate physics course. This study employed the one group pre-test – post-test experiment design with a sample of 32 students who took an undergraduate level basic physics course. Learning design and devices applied in this research have been validated by three experts in physics education. 'Schoology', a virtual learning management system, was used as the online learning platform. One cycle of inquiry phases was conducted in the blended learning format of 'pre-online–face to face–post-online learning'. The data were collected through tests, a scale, and a questionnaire. The test consisted of 35 multiple-choice questions with five alternative answers. It was designed to measure students' abilities in remembering, understanding, applying, and analyzing. The satisfaction scale ranging from 1 (strongly disagree) to 5 (strongly agree) consisted of 21 items and covered the attractiveness, ease of use, and benefits of learning using the learning products. Furthermore, the questionnaire consisted of six open-ended questions asking about the obstacles and benefits students faced during the learning activities. The results showed that the students' learning outcomes increased sufficiently. Besides, students' satisfaction with the learning design and materials was also positive. These initial findings imply that inquiry-based learning (IBL) may be implemented in physics teaching using a blended learning format that can be more effective and efficient.

Keywords: Blended Learning; Inquiry-Based Blended Learning (IBBL); Inquiry-Based Learning (IBL); Schoology, Students' Satisfaction

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How to cite: Suana, W. (2022). Inquiry-based blended learning design for physics course: The effectiveness and students' satisfaction. *Berkala Ilmiah Pendidikan Fisika*, 10(1), 126-134.

INTRODUCTION

Inquiry-based learning (IBL) impacts students' learning experts as a pedagogy approach. This approach promotes learning and leads to that quality of learning achievement through solving problems, constructing knowledge, developing high reasoning skills, and increasing interest and learning motivation (Avsec & Kocijancic, 2014). The other role emerges with students' engagement and thinking process, where they can construct new knowledge (Abdi, 2014). Moreover, giving students opportunities to be involved in the learning process can make them explore and understand new content knowledge themselves, thereby improving their

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learning outcomes (Abdi, 2014). Guided inquiry learning provides a powerful strategy of instruction for learners based on their learning experience and develops students' critical thinking skills (Longo, 2016; Pedaste et al., 2015).

IBL is a learning method that emphasizes students' discovery of new knowledge, not just memorizing information conveyed by their educators (Cairns & Areepattamannil, 2019). Meanwhile, according to Arends (2012), IBL is a pedagogic approach that aims to produce scientists who can develop and apply new knowledge from different thoughts through systematic questioning, proposing hypotheses, and conducting experiments. In recent research, the term IBL is based on a systematic literature review conducted by Pedaste et al. (2015). It is found that IBL as a pedagogic approach consists of several phases as a cycle, including orientation, questioning, hypothesis generation, investigation, conclusion, and communication (Pedaste et al., 2015).

In addition to the benefits of IBL, several challenges of implementing the learning method have been highlighted by several scholars. Gholam (2019) revealed that the problems related to implementing inquiry learning are the school system and lack of time for planning and preparation. The same difficulty is also addressed by Dorier & Maaß (2012), who found that improper support from the institution for giving training of curricula designed to instruct IBL is one of the barriers. Recently, the issue originates from overcoming the gap between the fixed time for instruction and assessment since inquiry learning needs a long-term learning practice (Khalaf, 2018). Facing this reality, it is important to develop a new inquiry learning approach that can be more effective and efficient of time.

As an alternative teaching-learning approach, blended learning refers to the model of learning that combines online and face-to-face learning (Bonk & Graham, 2012; Helms, 2014; Keengwe & Kang, 2013). Literature has noted the benefit offered by this model, such as improving student learning. The other advantages of blended learning are that students and teachers find it easier to interact more frequently. It is time-flexible (King & Arnold, 2012) and increases students' motivation (Oweis, 2018). Moreover, blended learning improves students' learning outcomes (Kazu & Demirkol, 2014; Poon, 2013).

Lately, a scholar has argued that well-planned IBBL can lead learners to work collaboratively and think critically (Longo, 2016). The previous study proves that IBL is more effective in supporting blended learning as it reflects multiple forms to meet the learning goal (Keengwe & Kang, 2013). However, little research has clearly stated the learning design combining the phases of IBL in a blended learning format. Therefore, this study intended to add the existing knowledge regarding the lack of knowledge regarding the mix between IBL and blended learning. Therefore, it can be formulated that the research questions of this experimental research. First, how is the effectiveness of IBBL design in enhancing students' learning outcomes? Second, how is the students' satisfaction regarding their learning activities in the IBBL system?

METHOD

This study is an experimental study to test the effectiveness of IBBL design and its learning materials using an experimental research design of one group pre-test–post-test design. This study included 32 undergraduate students of a basic physics course at one of the state universities in Indonesia from May to June of the year 2017.

Learning products implemented in this research consisted of learning design of IBBL, students' worksheets, handouts, videos, exercises, and a learning environment on Schoology of the basic version. Schoology was limited by only using the features of the announcement board, discussion, and test features. Before the treatment, three experts were asked to validate all of the learning products developed by the authors and gave some suggestions to improve their quality.

IBL cycle in this study was adapted from Pedaste et al. (2015), which implemented six main activities, namely observing phenomena, asking questions, designing experiments, collecting the data, drawing conclusions, and communicating the results. Meanwhile, the blended learning format employed was ‘pre-online learning – face to face – post-online learning’, for each learning cycle (Suana et al., 2019). The basic version of Schoology was used to manage the online learning sessions.

In the pre-online learning session, student activities were observing phenomena, asking questions, and proposing hypotheses through the discussion on Schoology. They then designed and conducted experiments in face-to-face meetings or searched for information in groups to reach conclusions. Furthermore, in post-online learning, learners returned to solve and discuss problems. This research was conducted for nine cycles in two months. The time for one learning cycle is one week. An illustration of the implementation of blended learning in this study is given in Figure 1.

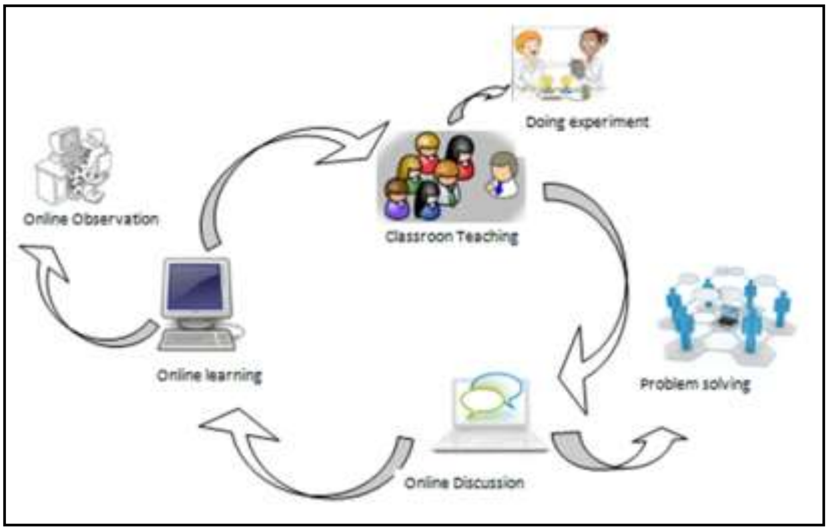

Figure 1 Illustration of IBBL

Meanwhile, the physics topics taught were electricity, static and dynamic electricity topics. The topic of static electricity was taught in four cycles, and dynamic electricity was delivered in five learning cycles. Table 1 shows examples of the IBL steps on static electricity in the format of blended learning.

Table 1 Examples of Blended Learning Activities

Subtopic	Inquiry Learning Activity	Mode	Time
Ohm's Law	observing the phenomenon of the light bulbs with different values of electric current, asking questions, and proposing hypotheses	Online (asynchro-nous)	Three days
	designing and conducting experiments on the voltage and current of the conducting wire, analyzing the data, drawing conclusions, and presenting the results	Face to face	1.5 hours

	Solving and discussing problems about the Ohm's Law experiment and wire resistivity	Online (asynchro-nous)	Three days
Electric Field	Answering and discussing the magnitude and direction of electric fields around point charges, and the electric flux of the different enclosed areas	Online (asynchro-nous)	Three days
	Observing the simulation of the electric field, performing group discussions about electric field around point charges, electric field lines, electric flux, and electric field by continuous charge distributions	Face to face	1.5 hours
	Solving and discussing problems regarding electric field generated by point charges and continuous charge distributions	Online (asynchro-nous)	Three days

Instruments used during the experiment consisted of tests, a satisfaction scale, and an open-ended questionnaire. They were validated theoretically by three experts in the field of physics education. The test consisted of 35 multiple-choice questions with five alternative answers. It was designed to measure students' abilities in remembering, understanding, applying, and analyzing. The satisfaction scale ranging from 1 (strongly disagree) to 5 (strongly agree) consisted of 21 items (Sugiyono, 2017). It covered the attractiveness, ease of use, and benefits of learning using the learning products. The test and scale have been evaluated for their validity and reliability. Furthermore, the questionnaire consisted of six open-ended questions asking about the obstacles and benefits students faced during the learning activities.

The data were analyzed using descriptive statistics, i.e. mean, standard deviation, frequency, and percentage. The success indicators were. Learning achievement data were presented using the score of 0 – 100 and then analyzed with mean and n-gain. The improvement of students' learning outcomes was categorized based on the n-gain, according to Maharani et al. (2017). Students' satisfaction was given in the average score (1-5) along with their criteria, and the last data from the open-ended questionnaire were tabulated and analyzed with frequency and percentage.

RESULT AND DISCUSSION

The experiment was conducted for two months in nine learning cycles, not including pre-test and post-test. Using the 'pre-online learning – face to face meeting – post-online learning' format, students participated in online learning first before face-to-face meetings to observe the physics phenomena through videos, ask questions and propose hypotheses, and carry out discussions with their classmates. They were guided to design and conduct experiments, analyze data, and communicate the results during face-to-face meetings. Students were given three-five questions to be answered and discussed with their peers during the online learning after the face-to-face activity. All online activities were performed asynchronously using the 'Add Discussion' feature of Schoology.

In all nine learning cycles, the number of posts in each online discussion was constant, with an average of 194.4 posts per learning cycle. With 32 students, each learner made on average 6.1 posts per cycle, more than three posts per online learning session. The number of posts between pre-online and post-online learning was balanced, which means that students were sufficiently active in online learning compared to the previous study (Suana et al., 2019). This may be because students were encouraged to comment at least once every online learning session.

The performance test shows the average of pre-test, post-test, and normalized-gain (n-gain), as shown in Table 2. Overall, the average initial students' dynamic and static electricity ability was very low, 36.6 out of 100. After implementing the blended learning model, the average ability of students increased to 61.4 with an n-gain of 0.39. When reviewed at every cognitive level, there was an increase at all levels with an n-gain of 0.28 to 0.39, moderate category (Maharani et al., 2017). This result indicates that blended learning design effectively enhances student learning outcomes. This finding aligns with previous works, where blended learning is more effective in improving students' learning outcomes (Kazu & Demirkol, 2014; Poon, 2013).

Table 2 Average of Students' Learning Outcome and N-gain

Average of	Overall	Remembering	Understanding	Applying	Analyzing
Pre-test	36.6 (6.18)	44.3 (15.4)	45.6 (14.6)	30.7 (14.8)	25.9 (11.0)
Post-test	61.4 (15.97)	69.4 (13.0)	68.4 (15.5)	59.7 (16.8)	48.1 (16.5)
n-gain	0.39 (0.11)	0.37 (0.41)	0.37 (0.34)	0.39 (0.31)	0.28 (0.27)

Furthermore, as seen in Table 3, students' perceptions of the attractiveness, ease of use, and benefits of the learning design are all categorized as 'good' since they are between 3.41 and 4.20 (Suana et al., 2017). This finding is in line with the study results reviewed by Kang (2014). It has been proved that blended learning effectively meets students' satisfaction and faculty's response to fully conventional or online classes. Furthermore, the attractiveness aspect earned the highest score, with the ease of use aspect being the smallest. Spanjers et al. (2015) also support this finding since it is similar to theirs, where blended learning environments with a particular assessment tool were, in general, more attractive for students. The present study's findings indicate better results compared to previous results obtained (Suana et al., 2017). In the previous study, the learning method used in the experiment was teacher-centred, while the current research used a student-centred learning technique. Moreover, the learning devices provided in the previous research were also fewer than those used in this study. Also, practice questions were not provided in the previous one (Suana et al., 2017). Thus, the present study has better teaching methods and learning devices which affect student perceptions.

Table 3 Students' Satisfaction with Blended Learning Design

Aspect	Item	Score	Average
Attractive-ness	Pre-online discussion is an interesting activity	4.16	4.01
	Post-online discussion is an interesting activity	4.03	
	practice questions are interesting to learn	4.16	
	Teaching materials are interesting to learn	3.81	
	overall, online class with Schoology makes physics learning to be more interesting	4.03	
	overall, the blended learning of 'pre-online learning – face to face – post-online learning' format is interesting to follow	3.88	
Easiness	I can easily participate in pre-online learning	3.63	3.65
	I can easily participate in post-online learning	3.56	
	Learning devices in the online class can be found easily	3.88	
	communicating with peers and lecturers in the online class can be done easily	3.94	
	Practice questions in the online class can be learned easily	3.63	

	• I have difficulties related to ICT / internet skills to join online learning on Schoology	3.53	
	• Overall, ‘pre-online learning – face to face – post-online learning’ can easily be followed without any significant constraints	3.38	
Benefit	• The blended learning system enhances my interest in physics learning	3.97	3.87
	• Pre-online learning activities improved my concept mastery	4.00	
	• Post-online learning activities improved my concept mastery	4.09	
	• Problem-solving activities improved my concept mastery	4.03	
	• I became more motivated to join the physics course using a blended learning model	3.72	
	• Based on my experience, I want to learn physics in a blended learning model	3.63	
	• The blended learning model improves my self-directed learning	3.88	
	• Overall, the blended learning model is more beneficial compared to face-to-face learning	3.66	

Data obtained from the open-ended questionnaire shows that the difficulty faced by most students in joining the blended learning technique is that of internet connection. About 30 students (94%) face these problems, ranging from error connection low speed to out-of-data plans. The challenges faced by students in accessing the internet and their lack of learners' ability to use technology have also been described (Kaliisa & Picard, 2017). A small number of students felt other problems, such as poor time management and limited online learning timeframe. These issues were also found by Schober & Keller (2012). These obstacles were likely to influence the lowest score of students’ perception of the ease of joining blended learning design. As illustrated in Table 3, the score associated with the easiness of participating in blended learning is only 3.38 (neutral category).

Meanwhile, the benefits of IBBL design had an average score of 3.87, which is a 'good' category (Suana et al., 2017). Then, from the data collected by an open answer questionnaire, it is found that the combined modes of learning are beneficial to the students since they have much time to understand the material being taught through a blended learning approach. Before face-to-face meetings, they have to prepare themselves to read the teaching materials, search for the answers to pre-online learning assignments, and review their friends' answers online. With online learning, students find it easy to discuss with friends anytime and anywhere without the bound of space and time. They can learn more easily. The teaching materials provided in online classes also facilitate their learning. Thus, this blended learning design provides ample time that allows learners to reflect on learning materials and discussion sessions (McDonald, 2012).

The main point of the inquiry-based teaching steps is to encourage students to be more active in the teaching-learning process (Abdi, 2014). Regarding the learning process, results obtained indicate that students learn more actively through online sessions and face-to-face meetings. They construct their understanding by observation, asking questions, and exchanging ideas with their peers through an online learning environment before the face-to-face meeting. In a face-to-face meeting, they construct the meaning through experiments or solving problems collaboratively. After face-to-face meetings, they have to solve problems independently and discuss them with peers. In this study, learners experience various learning approaches, including self-paced, independent, and collaborative learning. In other words, this inquiry learning step can enhance students' learning experiences since it provides a variety of learning methods for students (Keengwe & Kang, 2013), such as online and face to face discussion, experiments, and presentation.

Blended learning frameworks can provide educators and students with numerous adaptable instructional techniques, instructional technologies, interactive systems or learning resources which can be applied (Kabassi et al., 2016). In this case, the teaching method gives students more capacities for reflection (McDonald, 2012). It has been proven to be a good factor that improves students' learning experiences. Therefore, this present study requires students to construct new knowledge by themselves through various activities and thinking processes (Abdi, 2014).

The present study has tried to examine combining a blended learning system and inquiry teaching steps by using Schoology as online media. From the test results, it is obtained that there is a significant increase in students' ability on all four levels of cognitive ability, namely remembering, understanding, applying, and analyzing (see Table 2). This finding is similar to the previous research, which opines that blended learning is more effective in improving students' learning outcomes (Kazu & Demirkol, 2014; Poon, 2013; Suana et al., 2019).

Moreover, as seen in the satisfaction scale, it is found that the students' perceived attractiveness, ease of use, and benefits of the learning experience are all categorized as 'good'. This is in line with the increase in students' cognitive abilities. As stated by Chen & Yao (2016), the level of students' perceived satisfaction with blended learning had a vital role in its effectiveness. This indicates that the blended learning design of using inquiry learning pedagogy may be effective in physics learning. Thus, generally speaking, this design is recommended to apply in teaching physics to improve students learning outcomes.

CONCLUSION

This study has developed an effective IBL method using a blended learning approach for an undergraduate basic physics course. IBBL with the stages of 'pre-online – face to face – post-online learning' is indicated to be sufficiently effective for improving students' learning outcomes. In addition, students also gave positive responses to the learning design and tools used in this study. Even though nearly all learners encountered internet connection-related issues, their perceptions of attractiveness, ease of use, and benefits of the learning design and materials were all in a 'good' category (Suana et al., 2017). It argues that students' learning achievement and satisfaction in learning using the IBBL model could be higher than these results when the internet issues are resolved.

However, there are some limitations in this study that need to be considered. This research has a limited number of participants. Therefore, it needs to be implemented in different subject matters to gain a broader view. A comparative study with traditional IBL models is also necessary to do. How the students learn during the blended learning design has yet to be evaluated deeply. Finally, integrating other pedagogic methods in a blended learning system, such as problem-based and project-based learning, is needed to minimize the student-teacher gap and enhance better students' understanding of learning.

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